

JULY 1955



VOL. 47 • NO. 7

# Journal

AMERICAN  
WATER WORKS  
ASSOCIATION

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**Water Utility Safety Practice**

**Part 1—Need for Program**

**Part 2—Starting a Program**

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**Inflation and Water Rates**

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**Sizing Water Mains**

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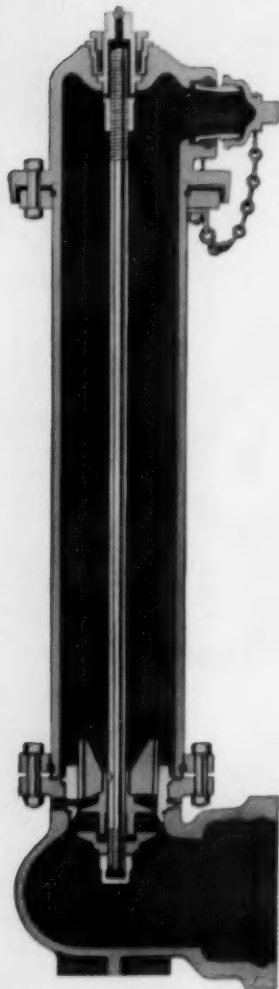
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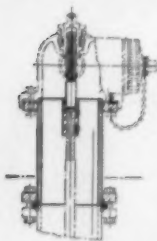
**Deep Well Vertical Turbine Pump Standards**

**ASA B58.1**

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# Journal

AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y.

Phone: MUrray Hill 2-4515

July 1955

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## Coming Meetings

### AWWA SECTIONS

**Sep. 7-9**—New York Section at Saranac Inn, Saranac. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand Street, White Plains.

**Sep. 12-14**—Kentucky-Tennessee Section at Phoenix Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, 553 S. Limestone St., Lexington.

**Sep. 14-16**—Michigan Section at Durant Hotel, Flint. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing 4.

**Sep. 19-21**—Rocky Mountain Section at Connor Hotel, Laramie, Wyo. Secretary, J. W. Davis, Dist. Mgr., Transite Pipe Div., Johns-Manville Sales, Inc., Denver, Colo.

**Sep. 21-23**—Ohio Section at Neil House, Columbus. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

**Sep. 21-23**—Wisconsin Section at Hotel Schroeder, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

**Sep. 25-27**—Missouri Section at the Connor Hotel, Joplin, Mo. Secretary, W. A. Kramer, Room 3, 6th Floor State Office Bldg., Jefferson City, Mo.

**Oct. 5-7**—North Central Section at Radisson Hotel, Minneapolis, Minn.

Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

**Oct. 16-19**—Southwest Section at Gunter Hotel, San Antonio, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Munic. Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

**Oct. 19-21**—Iowa Section at Hotel Fort Des Moines, Des Moines. Secretary, H. V. Pedersen, Supt., Water Works, Munic. Bldg., Marshalltown.

**Oct. 20-21**—West Virginia Section at Waldo Hotel, Clarksburg. Secretary, Harry K. Gidley, Director, Div. of San. Eng., State Health Dept., Charlestown.

**Oct. 20-22**—New Jersey Section at Hotel Madison, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Inc., Box 178, Newark 1.

**Oct. 25-28**—California Section, at Senator Hotel, Sacramento. Secretary, H. F. Jerauld, Asst. Supt., Constr. & Operation, Water Dept., 1040 Manzanita Ave., Pasadena 3.

**Oct. 26-28**—Chesapeake Section, at Sheraton Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955 —33rd St., Washington 15, D.C.

**Oct. 30-Nov. 2**—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

(Continued on page 8)

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**Coming Meetings***(Continued from page 6)*

**Nov. 3-5**—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanaugh, 213 Carlton Terrace Bldg., Roanoke 11.

**Nov. 6-9**—Florida Section, at Orange Court Hotel, Orlando. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica Burnett Chem. Co., Box 2328, Jacksonville.

**Nov. 14-16**—North Carolina Section, at Robert E. Lee Hotel, Winston-Salem. Secretary, W. E. Long Jr., 1615 Bickett Blvd., Raleigh.

**OTHER ORGANIZATIONS**

**Jul. 18-23**—International Water Supply Assn. Congress, London.

**Aug. 15-19**—Water and Sewage Plant Operators Short Course, at Virginia Polytech. Inst., Blacksburg. Administrator, J. D. Eye, Prof. of San. Eng., V.P.I.

**Sep. 12-16**—Short Course on Corrosion, at Washington Univ., St. Louis, Mo., sponsored by Washington Univ. and Greater St. Louis Section, National Assn. of Corrosion Engrs.

**Sep. 18-22**—New England Water Works Assn., at Lake Placid Club, Lake Placid, N.Y.

**Sep. 21-23**—Georgia Water and Sewage School, at Hightower Textile Bldg., Georgia Inst. of Technology, Atlanta.

**Oct. 10-13**—Federation of Sewage & Industrial Wastes Assns., at Ambassador Hotel, Atlantic City, N.J.

**Oct. 24-28**—American Society of Civil Engineers Convention, at Hotel Statler, New York.

**Oct. 24-26**—National Conference on Standards, at Sheraton Park Hotel, Washington, D.C., sponsored by National Bureau of Standards and American Standards Assn.

**Nov. 1-3**—Panel Conference on Underground Structure Corrosion, at Hotel Niagara Falls, N.Y., sponsored by Northeast Region, National Assn. of Corrosion Engrs.

**Nov. 14-18**—American Public Health Assn. Convention, at Municipal Auditorium, Kansas City, Mo.

**Nov. 16-18**—Water Works Management Short Course, at Univ. of Illinois, Alherton Park, Ill.

**Nov. 27-30**—American Institute of Chemical Engineers, at Hotel Statler, Detroit, Mich.

**Nov. 27-30**—National Chemical Exposition, at Public Auditorium, Cleveland, Ohio, sponsored by Chicago and Cleveland sections, American Chemical Society.

**Dec. 5-9**—Exposition of Chemical Industries, at Commercial Museum and Convention Hall, Philadelphia, Pa., under management of International Exposition Co., New York.

**Dec. 11-17**—Nuclear Engineering and Science Congress, Cleveland, Ohio, sponsored by Engineers Joint Council.

**1956**

**Feb. 13-18**—Symposium on Winter Concrete Theory and Practice, International Union of Testing & Research Labs. for Materials & Structures (RILEM), Copenhagen, Denmark. Organizing Secy., RILEM Symposium 1956, c/o Danish National Inst. of Building Research, 20 Borgergade, Copenhagen, K, Denmark.

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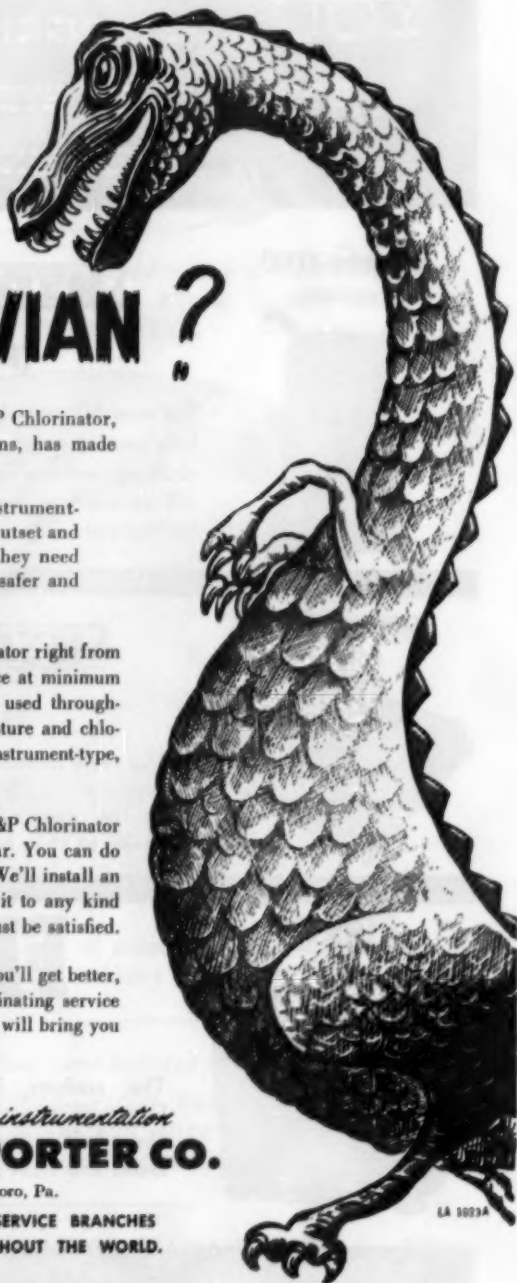
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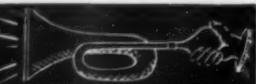
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(POWDER)



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**FIBREX**  
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The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.



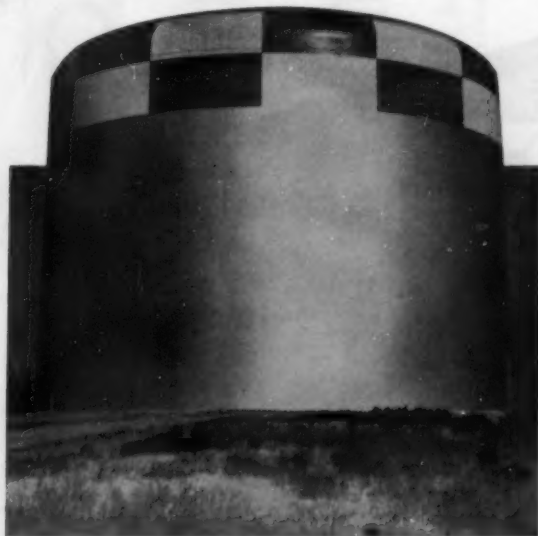
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# better!

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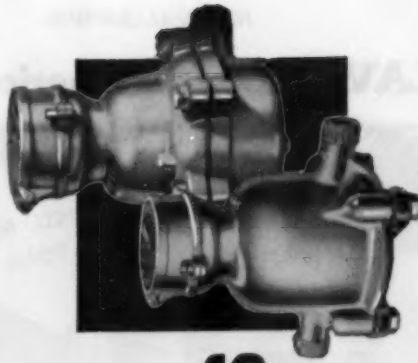
alone approximately 162 gallons of water  
per hide.

The Badger water meters used throughout the nation help conserve water for this need . . . just as they do for homes. They measure water accurately . . . provide a precise check on water usage and waste . . . make water departments more efficient and self-supporting.

As waterworks men everywhere verify, Badger meters do the job dependably . . . serve through the years with little or no attention.

# Badger Water Meters

Badger Meter Mfg. Co.  
Milwaukee 45, Wisconsin



"Measuring the water of the world for

50 years."

## DE LAVAL pumps America's water...



In Council Bluffs, Iowa, as in more than 80% of America's municipal stations, De Laval centrifugal pumps are faithful public servants.

On the line are two motor-driven De Laval 14/12 units. Each unit has two pumps in series designed for 4,500 gpm against a total head of 245 feet at 1,200 rpm.

Another pumping unit, dual driven by a gas engine at one end and a motor at the other, consists of two De Laval 12/10 pumps in series. Operating conditions for these are 3,750 gpm against a head of 235 feet at 1,200 rpm.

Fifty-three years experience in pump building, during which time De Laval has introduced numerous "firsts" in pump design, is the reason for this nation-wide preference.

### NOTE:

Have you considered the dollars and cents savings you can make by replacing your old pumps with new, more efficient De Laval units? Write to De Laval for Pump Fax bulletin which includes a valuable "power savings" chart.



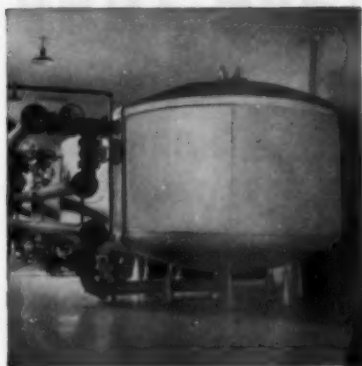
## DE LAVAL Centrifugal Pumps

DE LAVAL STEAM TURBINE COMPANY  
822 Nottingham Way, Trenton 2, New Jersey

# Why

## General Filter?

There are many reasons why municipalities and industries have installed General Filter water treating plants:



**INSTALLATION SUPERVISION** . . . General Filter "job-engineers" each installation to the consulting engineer's specification . . . supervise the installation and train the personnel who will work with the equipment.

**OPERATIONAL DEPENDABILITY** . . . for twenty years General Filter has concentrated all of its efforts toward "better water treatment". Their efforts have produced water treating plants and equipment that are completely dependable.

**GREATER ECONOMY** . . . the only real test of economy is a long term test. General Filter plants stand up over the years providing "better water" with minimum maintenance, longer trouble-free, smoother operation.

**ENGINEERING KNOW-HOW** . . . General Filter's design and construction engineers are familiar with the problems involved in water treatment.

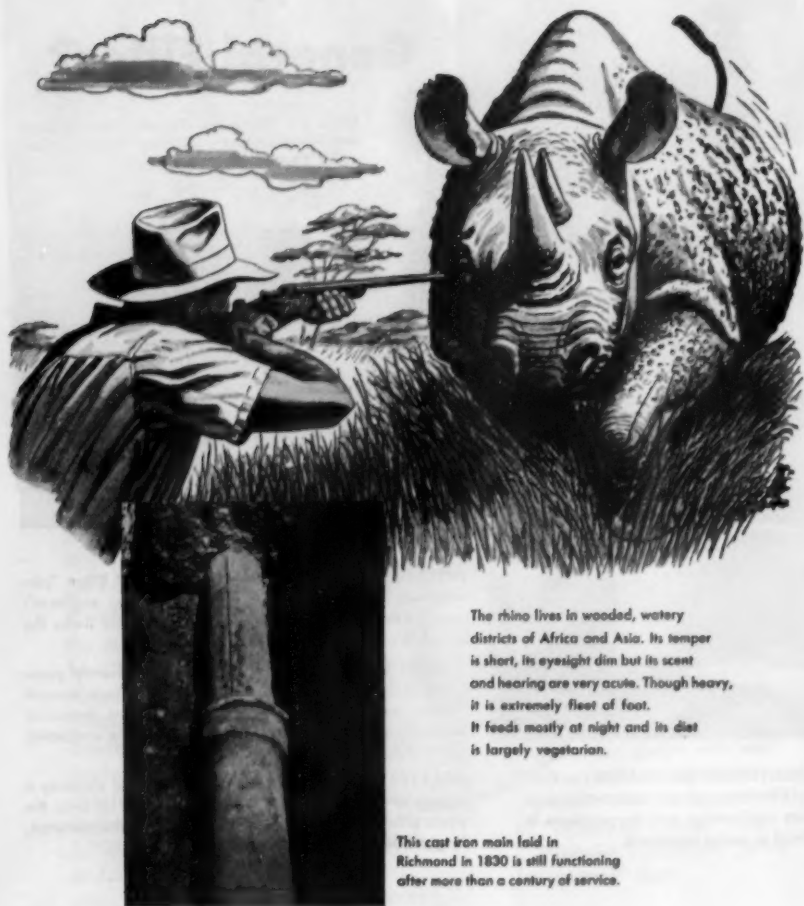
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# what have they



The rhino lives in wooded, watery districts of Africa and Asia. Its temper is short, its eyesight dim but its scent and hearing are very acute. Though heavy, it is extremely fleet of foot. It feeds mostly at night and its diet is largely vegetarian.

This cast iron main laid in Richmond in 1830 is still functioning after more than a century of service.

**MODERNIZED cast iron**

# in common...

## THE RHINO

## AND CAST IRON PIPE...TOUGHNESS!

The thick, tough hide of the rhinoceros makes it one of the hardest animals to bring down. Toughness is also a dominant feature of CAST IRON PIPE. It serves for centuries.

**AND HERE'S THE PROOF:** Listed below are some of the many water utilities still using cast iron pipe that was installed a century or more ago.

DEPARTMENT OF WATER AND WATER  
SUPPLY, City of Albany, New York  
ALEXANDRIA WATER COMPANY  
Alexandria, Virginia  
BUREAU OF WATER, DEPT. OF PUBLIC  
WORKS, Baltimore, Maryland  
PUBLIC WORKS DEPT., WATER DIVISION  
Boston, Massachusetts  
DEPARTMENT OF PUBLIC WORKS,  
DIVISION OF WATER, Buffalo, N. Y.  
WATER WORKS DEPARTMENT  
Chicago  
COLUMBIA WATER COMPANY  
Columbia, Pennsylvania  
BOARD OF WATER COMMISSIONERS  
Detroit, Michigan  
CITY OF FREDERICK WATER DEPT.  
Frederick, Maryland  
PUBLIC SERVICE COMMISSION  
City of Hartford, N.S. Public Water Supply  
WATER BUREAU OF THE METROPOLITAN  
DISTRICT, Hartford, Connecticut  
MUNICIPAL WATER WORKS  
Monteville, Alabama

BUREAU OF WATER  
Lancaster, Pennsylvania  
CITY OF LYNCHBURG WATER  
DEPARTMENT, Lynchburg, Virginia  
MOBILE WATER WORKS COMPANY  
Mobile, Alabama  
QUEBEC HYDRO-ELECTRIC COMMISSION  
Montreal, Quebec  
PUBLIC WORKS DEPT., WATER-WORKS &  
SEWERAGE DIV., Montreal, Quebec  
PENNICHUCK WATER WORKS  
Nashua, N. H.  
WATERWORKS DEPARTMENT  
City of Nashville, Tennessee  
DEPT. OF WATER, GAS & ELECTRICITY  
New York, New York  
DEPT. OF PUBLIC WORKS, BUREAU OF  
WATER, Philadelphia, Pennsylvania  
BUREAU OF WATER, DEPT. OF PUBLIC  
WORKS, Pittsburgh, Pennsylvania  
POTTSVILLE WATER COMPANY  
Pottsville, Pennsylvania  
BUREAU OF WATER  
Reading, Pennsylvania  
DEPT. OF PUBLIC UTILITIES (WATER)  
Richmond, Virginia

DIVISION OF WATER & SEWERS  
Sacramento, California  
WATER & SEWERAGE DEPARTMENT  
City of Saint John, N.S.  
DEPT. OF PUBLIC UTILITIES  
WATER DIVISION, St. Louis, Missouri  
WATER DIVISION, DEPT. OF  
ENGINEERING, Syracuse, New York  
DEPT. OF PUBLIC WORKS  
Troy, New York  
CITY OF UTICA, BOARD OF WATER  
SUPPLY, Utica, New York  
CITY OF WHEELING, WATER DEPT.  
Wheeling, West Virginia  
WILMINGTON WATER DEPT.  
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WATER DEPARTMENT  
City of Winchester, Virginia  
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City of Winston-Salem, North Carolina  
YORK WATER COMPANY  
York, Pennsylvania  
WATER DEPARTMENT  
City of Zanesville, Ohio

**TODAY...** modernized cast iron pipe, centrifugally cast, is even tougher, stronger, more uniform. *Where needed and specified*, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout its long years of service.

On its record, CAST IRON PIPE is the world's most dependable carrier of water.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director,  
122 So. Michigan Avenue, Chicago 3.

CAST IRON

The Q-Check standard on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

# pipe

FOR MODERN WATER WORKS OPERATION

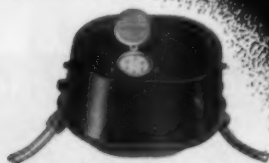
# The FORD Yokebox



## *A Better Meter Setting for Shallow Services*

A simple, compact meter housing, complete with service valve, for warm climate installations. The modern and better way to install water meters. Gives better protection, keeps meter cleaner. An investment in easier meter reading, longer meter life and greater revenue.

Write for information  
on the Yokebox.



1. Small lid, clean meter, speeds meter reading.



2. Easy to handle, quickly installed as a unit.



3. Meter changes quick and easy, without cumbersome tools.

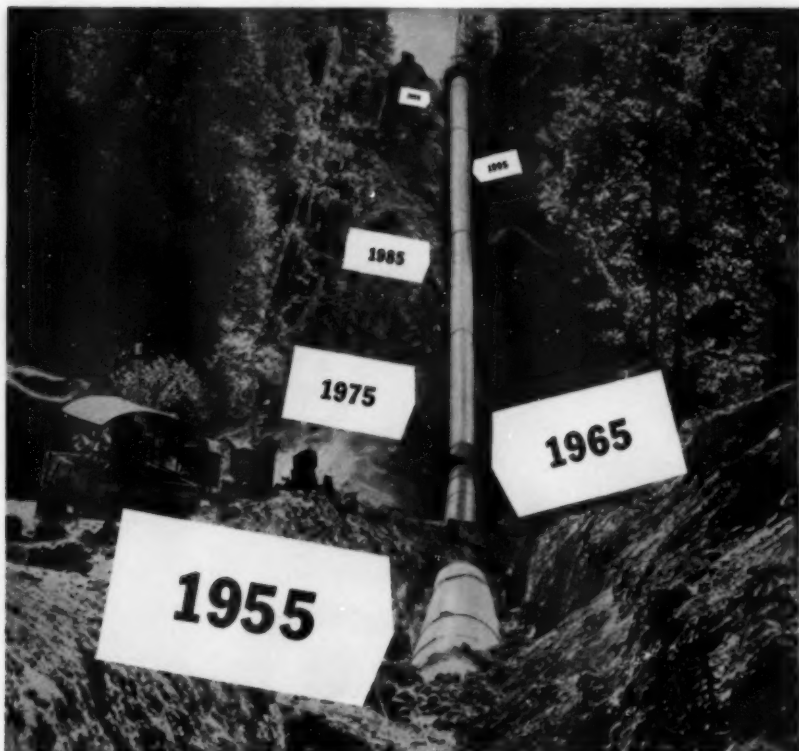


4. Service valve easily operated and well protected.

# FORD

FOR BETTER WATER SERVICES

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The words "good for a lifetime" have real meaning as far as the City of Portland's new 56-66-inch Bull Run water pipeline is concerned. With Barrett Protective Coatings applied inside and out along the entire 25 mile length, this line will resist all the elements and last indefinitely. Inside and out, from end to end, Barrett protective coatings did the job.

Members of Barrett's technical service corps recommended the protective coating best suited to Portland's specific needs, and helped supervise its application at the pipeline site. These services are available to all users of Barrett protective coatings.

Specify Barrett to get a high-quality waterworks enamel that meets all A.W.W.A. standards, plus expertly supervised application.

### HERE ARE TEN DEFINITE ADVANTAGES OF BARRETT WATERWORKS ENAMEL:

- Rigid quality control.
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- High dielectric properties
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- Prompt service
- Wide availability

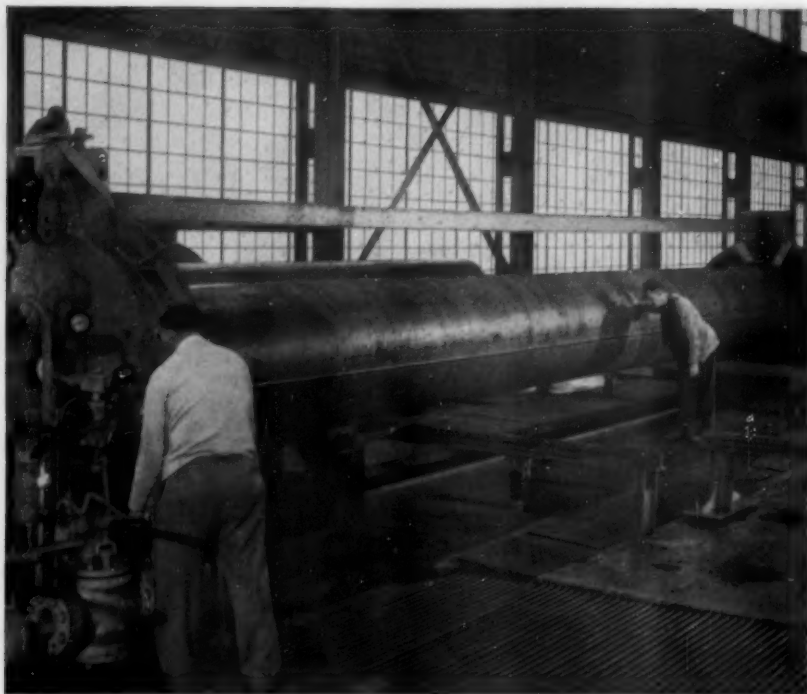


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OVER 100 YEARS OF EXPERIENCE





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Every length of steel pipe is hydrostatically tested to at least twice the required working pressure—or more—to suit your most rigid specifications.

And just as important, rugged steel pipe passes the tests of time—meeting exacting modern day demands for maximum service—whether it was installed yesterday or 50 or more years ago.

When the pressure is on you to select the best pipe, you're smart to specify STEEL pipe.

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**STEEL PLATE FABRICATORS  
ASSOCIATION**

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In addition to water softening, Cochrane Solids-Contact Reactors are used for clarification of surface waters for removal of suspended solids, turbidity, color, taste, odor; coagulation and reduction of alkalinity; removal of silica; removal of fluorides, etc.

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For complete details of Cochrane Solids-Contact Reactors, write for Publication 5001-A and reprints on Reactors.



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Economical protection from abrasion, submersion, condensation and humidity is achieved here with colorful, durable Inertol coatings: Glamortex® takes hard knocks; Torex® is made for submersion; Ramuc® Utility withstands condensation and an average 75% humidity during the winter.

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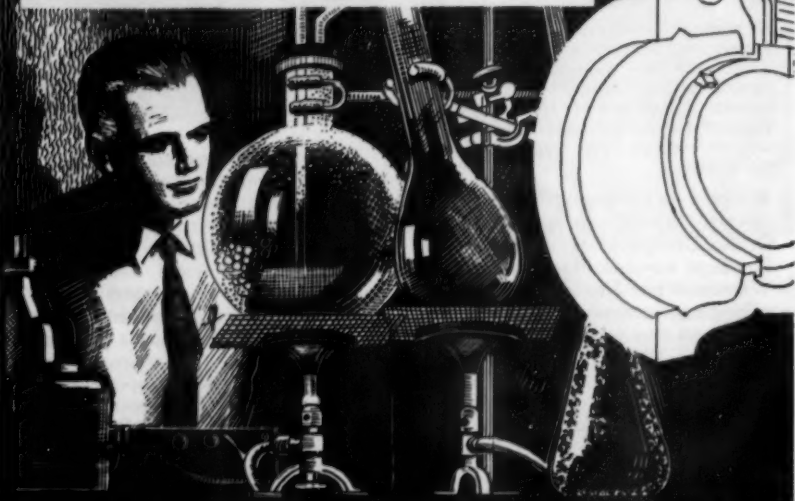


Perhaps we are prone to see only the more spectacular phases of modern research, such as the development of antibiotic drugs, television, or jet planes. As a matter of fact, modern life probably depends more on the development of more common products.

For example, consider valves and hydrants, which most people take more or less for granted but without which a modern water works could not function. And without water works, modern cities could not exist.

There is no romance about valves and hydrants, nothing spectacular. Yet M&H Valves and Hydrants are the products of many years of research in engineering, design, metal strength and structure, foundry practice, and water works operation.

These M&H products enjoy the confidence of engineers because they give top performance year-after-year in a service vital to the American way of life. For details, write M&H VALVE & FITTINGS COMPANY, Anniston, Alabama.



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FOR WATER WORKS • FILTER PLANTS  
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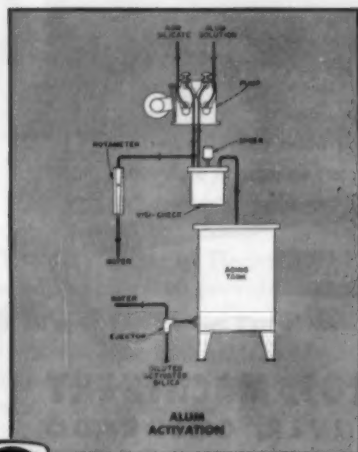
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Pekrul Gates means a *planned* water control project  
that will fulfill its purpose. It costs no more to plan with  
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Horton ellipsoidal-bottom elevated tanks, standpipes, reservoirs and radial-cone tanks are also available to meet your water storage requirements. Write our nearest office for an estimate or information.

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Utrecht, was the first city in Holland to try "Flexibles" shortly after the war. Without prior experience or demonstration, its water-works engineers were able to restore lines to 95% of original capacity, quickly and easily. Today, both Hi-Speed Rodding Equipment and Pressure Line Scrapers are being used daily throughout the entire country. Before and after reports in our files show uniformly good results. Proven tools and equipment are available to remove all types of water main deposits. For further details, write for the name of the distributors in your territory, or —

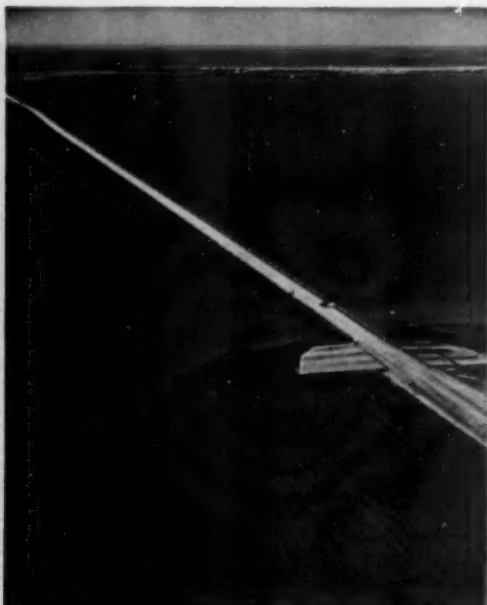
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Water Main Cleaning Manual*



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AMERICA'S LARGEST LINE OF PIPE CLEANING TOOLS AND EQUIPMENT



*Seafaring durability!* K&M "Century" Pipe "goes to sea" on the Padre Island causeway pictured here. The island is located off the Texas mainland. Engineers: Parson, Brinckerhoff, Hall and Macdonald, New York. Installation contractor: W. T. Liston Co., Harlingen, Texas. Photo by Booth Studio.



*In the south!* "Century" Pipe is shown here at the beginning of the Padre Island causeway—a span that stretches out from the coast of Texas into the Gulf of Mexico for a mile and a quarter.



*In the east!* This picture illustrates an installation of "Century" Pipe at the Brookwood Estates, Stanhope, New Jersey.

## Over the Sea, as across the Land K&M "Century"® Pipe Keeps Pumping Costs Low!

Off the coast of Texas, the "Century" Pipe on the causeway pictured above prevents pumping costs from creeping up—there's never a change in the diameter of its bore! Why? This asbestos-cement pipe is non-tuberculating, highly resistant to corrosion, and immune to electrolysis.

Formed on a smooth steel mandrel, its interior surface offers a minimum of friction. The Williams and Hazen Constant "C" is conservatively placed at 140. As this pipe is relatively light in weight, handling and installation costs are low. It also meets the A.W.W.A., and A.S.T.M., and Federal

specifications for asbestos-cement pressure pipe.

**Contraction, expansion controlled.** The "Century" Simplex Coupling acts as an expansion joint. Each pipe length "floats" within its own couplings. Thus, any contraction or expansion need is readily met. Furthermore, these couplings actually absorb traffic vibration.

**Booklet on request!** Write for your copy of "Mains Without Maintenance"... complete specifications and background data for K&M "Century" Pipe. There's no obligation, of course.

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# CHAPMAN'S

*Beamed Waterway*

## GATE VALVE

has 6 to 10 Times  
More Bearing Contact Area  
longer life,  
lower maintenance

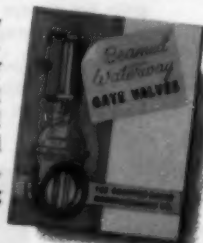


Chapman's Beamed Waterway Gate Valve has been giving excellent service in Filtration Plants and is especially suitable for Wash Water Valve Service, or other similar limited throttling conditions.

In the partly open position the Beamed Waterway Valve has six to ten times more bearing contact surface than other double disc parallel seat gate valves or square bottom gate valves.

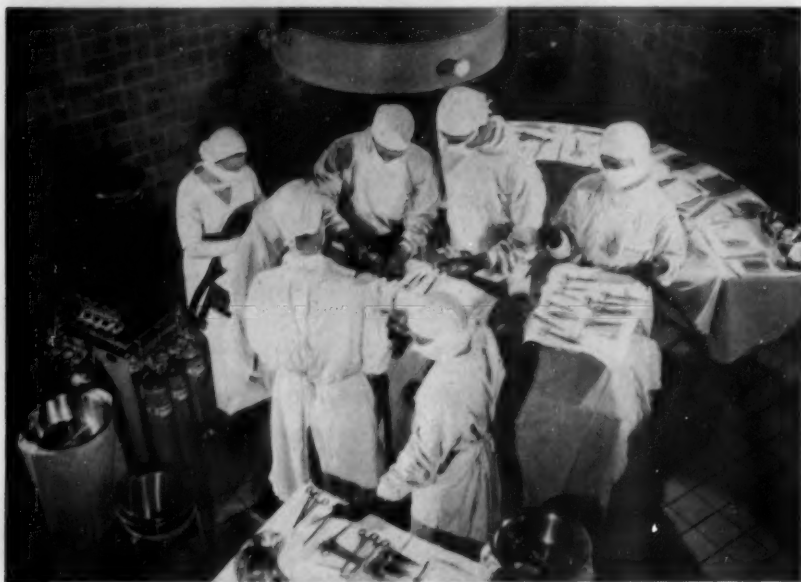
Even after decades of severe service, Chapman Beamed Waterway Gate Valves still seat snugly with little or no leakage. Bronze bearing surfaces on beams and downstream discs ensure minimum wear.

Beamed Waterway Gate Valves are available in all sizes of Lists 58½, 59½ and 61 gate valves and with any desired method of operation. Write for Catalog No. 45 today.



**THE CHAPMAN VALVE MANUFACTURING COMPANY**

INDIAN ORCHARD, MASSACHUSETTS



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*. . . Strength in Depth*

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The W&T field organization, all of whom are factory trained and qualified, is always available on short notice to supervise the installation of W&T equipment, to render service and assistance regarding your chlorination or chlorinator problems, and to provide equipment and service in times of disaster.

W&T research and development engineers are always seeking out new designs, principles and materials. W&T chemists and bacteriologists are always trying to find new processes for the improvement of water and sewage treatment.

When you depend on W&T equipment, you have the assurance that 40 years of experience by this team is being used to bring you the best in service, design and dependable performance.

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# Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 47 • JULY 1955 • NO. 7

## Safety Practice for Water Utilities

### *AWWA Manual*

**A**FTER several years of study, AWWA Committee A2.E—Safety Practices has prepared a manual of safety practice for water utilities. The document is divided into four parts, the first two of which appear in this issue. Part 3, because of its length, will be published in several successive issues. When serialization is completed, the manual will be made available as a separate volume for easy reference. An abbreviated table of contents follows:

#### Part 1—Need for Safety Program

#### Part 2—Starting and Maintaining Program

#### Part 3—Safe Working Practices

- Sec. 1—General Safe Practices (personal protective equipment, first aid, lifting and lowering, scaffolds, machine guards, etc.)
- Sec. 2—Hand Tools (axes, chisels, saws, shovels, etc.)
- Sec. 3—Portable Power Tools (electric, pneumatic, metalizing, etc.)
- Sec. 4—Storerooms and Stockrooms
- Sec. 5—Vehicle Driving
- Sec. 6—Working in Manholes
- Sec. 7—Building Operation and Maintenance
- Sec. 8—Fire Protection
- Sec. 9—Trench Construction (hand digging, trenching machines, and shoring)
- Sec. 10—Blasting Operations (storage, handling, and use of explosives)
- Sec. 11—Power Shovels and Draglines
- Sec. 12—Pipe (handling and storage)
- Sec. 13—Lead and Calking Compounds (melting and handling)
- Sec. 14—Barricades and Warning Signs
- Sec. 15—Concrete Mixers
- Sec. 16—Hoist Operations

- Sec. 17—Pumping Stations (oiling, repairs, metal guards, etc.)
- Sec. 18—Diesel and Gasoline Engines
- Sec. 19—Wells (drilling and housing)
- Sec. 20—Automotive Equipment
- Sec. 21—Gas and Arc Welding
- Sec. 22—Elevated Tanks
- Sec. 23—Chemical Handling, Storage, and First Aid (activated carbon, alum and ferrous sulfate, ammonia, ammonia sulfate, carbon dioxide, chlorine, fluorides, lime, soda ash, and sodium chlorite)
- Sec. 24—Bacteriological and Chemical Laboratories (general laboratory precautions, apparatus, chemical reagents, incompatible chemicals, compressed gases, maintenance, and personnel)
- Sec. 25—Office Worker Safety

#### Part 4—Bibliography of Safety Information Sources

### Committee Personnel

R. J. FAUST, *Chairman*

E. J. ALLISON  
J. G. COWAN  
K. A. DAY  
R. A. EDWARDS  
EARL FREDRIKSEN  
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H. L. ROOSE

J. C. ZUFELT

The information contained herein is drawn from sources believed to be reliable. The safety suggestions are based on the injury prevention experience of the committee members, as well as of other professional safety engineers, water works superintendents, and others. The American Water Works Assn. makes no guarantee of results and assumes no liability in connection with the information herein contained. Moreover, it should not be assumed that every acceptable safety procedure is contained herein; or that abnormal or unusual circumstances may not warrant or require other procedures. These suggestions should not be confused with either state or national safety codes.

## Part 1—Need for Safety Program

Water utilities need planned safety programs because far too many employees suffer disabling injuries. Although such injuries are not apt to be as serious as those of gas and electric utility workers, National Safety Council records show a much greater frequency of injuries in the water works field.

This situation is not necessary, as shown by the Akron Water Dept. (1). In 1952, only one lost-time injury was recorded in 447,095 man-hours (2). This achievement—which earned the National Safety Council's award of honor and a congratulatory resolution from the city council—was the direct result of a carefully planned and enthusiastically managed safety program.

Assembled through the cooperation of AWWA members, safety engineers, equipment manufacturers, and other interested groups, this manual proposes that every water utility should and can have an effective safety program. The publication has been prepared with the conviction that any operating executive can secure the necessary support from his board, council, or commission. It is believed that no city council, public official, or private director will refuse to support an inexpensive program which concretely promises to improve service, cut costs, provide better employee morale, and promote public goodwill.

The two functions of the manual are to offer guidance in the formulation and conduct of safety programs and to provide codes of safe practice for the common operations or working conditions encountered by water works employees. The goal of those who prepared the work has been to provide

material which will be as helpful to the small-system superintendent as to the executives of larger organizations.

A 1945 survey of water utilities showed that 15,606 water systems served communities of 10,000 or less, while 1,141 systems served larger communities (3). Applying a ratio of one employee to every 1,000 people served, it is obvious that the great majority of water utilities have no more than ten workers. Even allowing for the rapid growth which has taken place in the last 10 years, it can be assumed that

TABLE 1  
*Injury Rate Comparisons*

Utility	Frequency Rate	Severity Rate *
Communications	1.22	100
Electrical	9.43	1,550
Gas	12.92	870
Water	23.19†	930†

\* Severity rate base was changed at the end of 1954 by ASA from 1,000 man-hours of exposure to 1,000,000.

† Based solely on the water utilities that have membership in the National Safety Council. As there were fewer than 50 such water works in 1933, only a relatively small segment of the industry is represented.

there are at least ten systems employing ten men or less for every system employing a larger number.

Safety should be a major concern of every water works management and can be of essential importance to the proper operation of a small system. When one worker of a total of five is laid up, the effective working personnel is reduced by 20 per cent, a substantial amount, and one complete job function may be left uncovered. There is no organization too small to benefit by planned safety thinking and training.

### Calculating Injury Rates

The most convincing evidence of the need for safety programs in the water works field is found in the utility injury rates compiled by the National Safety Council. By applying formulas developed by the American Standards Assn. (4) and used by the council, any executive can quickly evaluate the position of his own organization in terms of injury frequency and severity.

The injury frequency rate is defined as the number of disabling injuries for each 1,000,000 man-hours of work. Disabling injuries are those which

charged\* for each 1,000,000 man-hours of work, and may be calculated by multiplying the number of days lost or charged by 1,000,000 and dividing the product by the total number of man-hours worked.

Injury rates may be given for any time interval; however, for comparison purposes, they are usually presented on an annual basis. The development of statistics for an individual organization calls for no more than maintaining a record of disabling injuries, including the number of days lost or charged in each case. With the total number of man-hours worked

TABLE 2  
*U. S. Bureau of Labor Statistics' Injury Rate Survey, 1953*

Employees per Utility	Utilities Reporting	Total Employees	Frequency Rate	Severity Rate
Less than 5	1,631	2,857	13.2	2,200
5-9	479	3,211	17.2	2,700
10-24	486	6,536	20.4	2,000
25-49	331	9,744	26.4	1,700
50-99	92	6,233	29.6	1,600
100-249	58	8,641	27.9	1,400
250-499	28	9,679	31.5	1,000
500-999	9	5,864	22.3	600
1,000 and over	7	11,691	20.4	1,100

cause death, permanent impairment, or a temporary inability to handle an employee's regular work on one or more days following the day of injury. Cases that call for first aid or medical treatment but do not involve permanent physical impairment or the inability to report for work on the following day are not classified as disabling injuries.

The frequency rate is found by multiplying the number of disabling injuries by 1,000,000 and dividing the product by the total number of man-hours worked. The severity rate is defined as the number of days lost or

available on time records, determination of both frequency and severity rates is a matter of simple arithmetic.

For example, suppose that in a 10-man system, whose employees work a 40-hr week, 50 weeks of the year—a total of 20,000 hr annually—one lost-time injury occurs, resulting in the loss of 5 days of work by the injured person. The frequency rate works out thus:

$$1 \times \frac{1,000,000}{20,000} = 50$$

\* An arbitrary, average amount of lost time per type of injury.

The severity rate works out thus:

$$5 \times \frac{1,000,000}{20,000} = 250$$

### Comparison of Injury Rates.

The figures compiled in 1953 by the National Safety Council provide a comparison of injury rates for four types of utilities (see Table 1). On the basis of these data, employees of water utilities suffered disabling injuries at about 1.8 times the rate for gas utility employees, 2.5 times the rate for electric utility employees, and 19 times the rate for communication

utilities, 64,456 employees, and a total of 133,411,000 man-hours worked during 1953. The frequency rate for disabling injuries for these utilities was 22.2, and the severity rate 1,600. The BLS frequency rate compares favorably with that of the National Safety Council, but the severity rate is 1.72 times greater. Thus, in accordance with BLS rates, the water industry in 1953 held an unenviable safety position among the utilities. The survey data are presented in Table 2.

TABLE 3  
*Industry-wide Injuries\**

Accident Source	Per Cent of Total Injuries
Handling objects	26
Falls	18
Falling objects	11
Machinery	10
Hand tools	7
Striking objects	7
Other	21

\* Assembled from industrial compensation figures provided by nine state labor departments.

utility employees. Because, on the whole, water works operations do not present the hazards faced by those working with gas or electricity, the severity rate comparison gives water utilities a more favorable position.

A second and much more complete analysis of safety conditions in the water works industry was made by the US Bureau of Labor Statistics (BLS) through a questionnaire survey conducted during 1954. A total of 3,121 usable questionnaire forms were returned, representing 2,598 publicly owned and 523 privately owned water

TABLE 4

*Water Works Injuries at  
Kansas City, Mo., 1953\**

Source of Accident	Per Cent of Total Injuries	Per Cent of Total Injuries Other Than Dog Bites
Handling objects	31	34
Falling objects	13	15
Dog bites	10	
Falls	8	9
Stepping on or striking objects	8	9
Machinery	7	8
Automobiles	5	6
Burns	4	4
Hand tools	3	3
Other	11	12

\* Data supplied by Kansas City Water Dept.

A breakdown of the BLS frequency and severity rates by number of workers employed indicates that the highest injury frequency rates are found in utilities with 250-499 employees. Although the lowest frequency rate belongs to the utility group employing less than five, this statistic is probably open to question because of the relative smallness of the total number of employees in the group. It is evident that the safety record of the water industry is not good. It compares with

some of the high-hazard activities such as logging, mining, and construction.

### Injury Classifications

Water works employees are injured by much the same kind of accidents that incapacitate workers in industry generally (compare Tables 3 and 4). Once the rather specialized hazard of dog bite has been removed from consideration, 55 per cent of all injuries reported by the state labor boards and 58 per cent of the injuries sustained by Kansas City water em-

28.4 per cent of the time lost from work. This statistic provides an excellent example of the value of maintaining accurate injury records, for it is through the study of such data that the areas of greatest risk can be ascertained, the reasons determined, and the corrective measures applied.

The BLS survey indicates that construction laborers account for nearly half (49 per cent) of the industry's disabling injuries and 37 per cent of the total time charged. The next highest category of injuries also involved laborers, but those with duties not related to construction. This group accounted for 6.9 per cent of the water works' injuries. Thus, laborers were involved in 55.9 per cent of all injuries occurring in the water utilities in 1953.

TABLE 5  
*Parts of Body Most Frequently Injured\**

Injured Part	Per Cent of Total Injuries	Per Cent of Total Compensation
Eyes	4	3
Head†	6	9
Arms	9	12
Trunk	27	28
Hands	9	6
Fingers	16	13
Feet	8	6
Toes	4	2
General	5	9

\* Data from reports, mostly 1951, of eight state labor departments.

† Except eyes.

ployees fall in the same three topmost categories. The principal safety problems of the water utility are not unique and special, but are those which the whole industrial community faces and which can be solved by safety thinking and training along well charted lines.

The parts of the body most frequently injured are the trunk and the fingers (see Table 5). The types of injuries sustained are shown in Table 6. The serious consequence of fractures is particularly noteworthy. Although responsible for only 10.8 per cent of the injuries, they accounted for

### Cost of Injuries

The pain and suffering endured by an injured employee cannot be assessed in dollars and cents, but every disabling injury brings in its wake a whole array of computable costs. There are direct expenses: medical, hospitalization, and compensation. Even greater—often up to four times as large—are the indirect costs. These usually include:

1. Time lost from work
2. Loss in future earning power
3. Economic loss to employee's family
4. Time lost by other workmen
5. Efficiency loss because of breakup of crew
6. Time lost by supervisor
7. Cost of breaking in new employee
8. Damage to tools and equipment
9. Time damaged equipment is out of service
10. Spoiled work
11. Miscellaneous (there are at least 100 other specific items which may be

directly charged against any particular accident).

Every disabling injury imposes a financial burden on the victim, the utility, and the customers it serves. Safety programs not only prevent human suffering, but they have a dollar and cents value which cannot be ignored.

The BLS estimates that approximately 5,300 workers in the water industry were disabled by injuries during 1953. The losses resulting have been estimated at 408,000 man-days and \$12,500,000.

the higher the insurance rates. As the insurance is subject to the laws of the individual states, premiums are based on state figures. Two factors work to reduce an individual concern's premium rate: The first is an improvement in the statewide injury record for any given industry. The second is the individual improvement shown by an employer with enough personnel to constitute a reliable sample of experiences.

The so-called manual rates are determined by dividing the entire industrial operations of a state into classifi-

TABLE 6  
*Types of Injuries\**

Injury	Number of Accidents	Per Cent of Total	Time Lost <i>hr</i>	Time Lost <i>per cent</i>
Bruises, contusions, cuts & lacerations	32	43.2	2,188	40.7
Sprains & strains	21	28.4	928	17.3
Fractures	8	10.8	1,528	28.4
Burns	5	6.8	176	3.2
Eye injuries	4	5.4	108	2.0
Miscellaneous†	4	5.4	440	8.4
Total	74	100.0	5,368	100.0

\* Data from Kansas City, Mo., Water Dept., 1952.

† Hernia, heatstroke, and two dog bites.

Striking evidence of the cash value of safety programs is found in their effect on the premiums paid for workmen's compensation insurance. In 1937, the Akron Water Dept. paid a rate of \$2.28 per \$100 of payroll. By 1949 planned safety thinking and safety training had brought the rate down to \$0.53 per \$100 of payroll, a reduction of 76.7 per cent.

The whole premium structure of workmen's compensation insurance is based on the risks attendant upon each type of industrial activity; the higher the injury frequency and severity rates,

cations according to hazard. An average rate for each category is then computed, based upon the total losses of all employers as compared with their total payrolls. Because an average business is as hypothetical as an average man, it is obvious that some risks—the term by which employers are known to the insurance companies—will be better than average, while others will be worse. The widely employed experience rating plan provides a technique by which rates are tailored to the injury records of the individual employer, giving credits for good rec-

ords and assessing debits for those that fall below average. The insured must be paying premiums above a certain amount, however, and must employ enough workers to present a reliable sample of experiences. A very large concern can make its rate entirely on its own record, but every water utility has a stake in improvement of the industry's injury record.

### Widespread Benefits

Safety stimulates efficiency, improves service, increases and protects earn-

ings, builds employee morale, and promotes better public relations. Truly, everybody benefits. For proof that a safety program can profit a water utility, consider the excellent progress made by the East Bay Municipal Utility Dist., Oakland, Calif., and the Dept. of Public Utilities, Richmond, Va., in 4 years with an active safety program (see Table 7). During 1954, the employees of the former set a record of 1,105,352 man-hours, with no lost-time accidents, between Apr. 7 and Sep. 21. As fine as this record is, it will undoubtedly be shattered in the future.

The planning, organization, and continuing maintenance of a safety program—one of the best investments available to a water utility management—pays handsome dividends. There is a right way to do every job, and that way is the safe way. This safety manual lists the correct method of handling nearly every task and type of equipment with which a water works employee may come into contact and is offered as a basic tool for use by all who have the best interests of the water utility industry at heart.

TABLE 7

#### Reduction of Injuries by Safety Program

Year	Lost-Time Accidents	Time Lost days	Time Worked man-hours	Injury Frequency Rate
East Bay Municipal Utility Dist.*				
1954	15	134	2,313,128	6.49
1953	27	324	2,352,416	11.48
1952	61	6,621†	2,424,632	25.16
1951	54	348	2,334,256	23.13
Dept. of Public Utilities‡				
1954	16	162	965,800	16.6
1953	27	326	968,725	27.9
1952	47	970	970,700	48.4
1951	45	2,461§	994,150	45.3

\* Oakland, Calif.

† 6,000 days are chargeable to one accident.

‡ Richmond, Va.

§ Includes time for 35 per cent loss of one leg and 10 per cent loss of the other by one employee.

### References

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### Willing Water Says:

Efficient production requires the prevention of accidents to employees.

## Part 2—Starting and Maintaining Program

Regardless of the size of a water utility, and the complexity of organization, a productive safety program depends on the active support of management. The top man must not only talk safety but show by his own actions that he means what he says.

In the typical small system, employing half a dozen men or less, the safety-minded superintendent or manager has to be his own safety director along with all the other functions he performs. He trains each individual employee in ways of eliminating accidents, and he also is the one who must personally see to it that working conditions are made safe.

In medium-size utilities, the details have to be entrusted to some other member of the organization. In large systems, it may be advisable to make the direction of safety thinking and training a full-time job. Without the whole-hearted support of the executive head of the utility, however, no deputy can achieve good results. The latter's responsibility and authority should be fully defined, and his function as safety director, safety engineer, or safety inspector should be made known to all.

In a large utility, a safety-minded management will not only back the man in charge of safety when he advises and instructs personnel, but will also accept and promptly act on his recommendations for building safety into the job. The surest way to let employees know that the "safety man" deserves respect is to correct the conditions which he tells management should be changed. The person who can get the boss to take prompt action in eliminating a hazard will be listened to when he tells somebody down the line how to do his job the right—and safe—way.

### Five Key Steps

Whether a utility has five employees or 500, the job of preventing accidents embraces these simple, common-sense steps:

1. Keeping injury records
2. Locating the hazards
3. Making equipment, plant arrangements, and working methods safe
4. Getting employees interested in safety
5. Controlling work habits.

The principles behind these steps do not change; ideas that have proved themselves in big operations will work in small ones. There is only one difference between the two when it comes to making a safety program function. In the larger organization, it becomes necessary to work through foremen and supervisors, while developing the enthusiastic cooperation of all who work under them. This requires the use of channels of communication which the small-utility superintendent does not have or need. His is pretty much a man-to-man job all along the line.

Because it is the purpose of this manual to help water utilities of all sizes to eliminate accidents, references are made, in discussing each step, to the variations in method occasioned by the size of the system.

### Accident Records

The first signpost to safety is found in a study of the accidents that occur and the resulting injuries. Essential information exists not only in the record of disabling injuries that require medical care and cause lost time, but

also in a listing of all minor injuries and accidents, including those which do not even require first-aid treatment. Three men may be tripped by a loose floor board without suffering more than bruises of loss of dignity, while the fourth man may break his leg.

At the beginning, it may prove desirable to go back through the absence record for at least a year or two, seeking to identify any lost time caused by injuries. It also may prove worthwhile to interview employees or foremen in an effort to check on any non-disabling accidents which have occurred. Making full allowance for faulty memories and the play of the imagination on recalled incidents, hazard patterns will emerge which can be checked as accurate records are maintained.

The care taken in keeping records—including all information—is more important than the form. A simple notebook can be used. A prepared form, however, as suggested in Fig. 1a and 1b, has definite advantages. In a small system, the form helps the superintendent make sure that he will get all the pertinent facts written down. In larger systems—where different people are apt to make reports—it is almost essential to accurate and uniform reporting. Everyone who supervises other workers should be supplied with copies, and one, filled out as completely as possible, should be promptly handed in to the superintendent or safety director whenever an accident occurs. It is important to insist that this be done even if no injury results.

A good way to establish such a habit is to require that every supervisor turn in a form once a week marked "No Accidents" when none have occurred. This reminds the supervisor

of his obligation to keep track of accidents and serves as a check on any failure to report minor mishaps at the time of their occurrence. The superintendent of the small system will find it equally helpful to keep the same kind of weekly "No Accident" notation on forms or in his notebook.

The value of properly organized record forms is twofold. They greatly simplify the preparation of reports to workmen's compensation authorities and insurance companies and provide adequate data on which to base analysis of hazards and determination of the corrective measures required.

In analyzing accident information, it is helpful to employ a chart of the type shown in Fig. 2. This gives a continuing and easily understood record of accidents, spotlights hazards before injuries occur, and makes it simple to visualize progress achieved under the safety program. The form is an effective tool for the education of employees and for securing the support of higher management, as well as the boards, commissions, or councils which may have to approve policies and budgets. Even in a very small system, the use of formalized reports and charts will prove worth while. They help the superintendent, busy with a great many responsibilities, focus his attention on safety matters and speak for him when he goes before his superiors.

### Searching Out Hazards

Accident records point to hazards that have already created trouble and that may bring more serious consequences in the future. Next, the exact cause of each accident, disabling or otherwise must be determined. Where tools, plant conditions, or working methods are at fault, prompt action

can be taken to eliminate risks. It is not enough, however, to wait for accidents to reveal such hazards; one of the principal goals of a safety program is to locate accident producers before they interrupt work and bring injury.

It is a primary function of this manual to provide a checklist against which the superintendent or safety director can assess each aspect of his system's operation. A good way to begin the tally is to go through the contents, noting those sections which apply to the plant setup and working arrangements in the individual utility. Many of the sections—such as those dealing with use of hand tools, safe driving, and other common operations—hold helpful information for everybody. Some parts, of course, deal with processes and plant conditions found only in certain systems.

Next, a careful reading of each applicable section is recommended. Many find the best guidance from material is secured if they take notes as they read, marking the points closest to their own interest or experiences. The very act of note taking stimulates thinking and invites closer observation of conditions and practices.

Using the manual as a guide, a series of physical inspections should be undertaken, in company with the man on the job or with the supervisors. So many injuries are caused by little things: slippery floors, cluttered work areas, defective tools, or exposed moving parts. Often, risks may be substantially reduced by simple, good housekeeping—keeping things where they belong.

It is helpful, too, to get outside advice. Insurance companies handling compensation and liability coverage maintain safety guidance departments

with experienced engineers available for inspection and consultation service. Industrial plants in the community have problems similar to those of water works and are usually glad to lend their safety man for an inspection tour. Various departments of a municipal government—even in a fairly small city—have experience or knowledge that can prove valuable.

With new equipment and processes constantly coming into use, special care should always be taken to investigate possible hazards connected with them. If any special training is necessary, this should be insisted upon as a condition of purchase. A full explanation of operating methods should be required of the manufacturer, and in case of doubt about safe procedures, it is advisable to make prompt inquiry of the insurance company handling compensation. Information can also be secured from the National Safety Council, 425 Michigan Ave., Chicago 11, Ill.

Perhaps the most important thing to remember about the job of searching out hazards is that it can never stop. A first check is essential in starting a safety program, but it is consistent followups that keep it alive.

### **Integrated Safety Procedures**

Nothing prevents accidents as effectively as the elimination of their causes. In the long run, this approach is more reliable than one which depends entirely upon the care taken by workers in doing their jobs. To preach safety while permitting unsafe conditions to prevail is bound to create an obstacle to the cooperation required from employees. Only when safety is integrated into the job are workers convinced that the man at the top wants to prevent accidents. These

## ACCIDENT REPORT

Date this report \_\_\_\_\_

Person reporting \_\_\_\_\_ Name of injured person \_\_\_\_\_

Check (for employees only) \_\_\_\_\_ patient injury

\_\_\_\_\_ First-aid case, or \_\_\_\_\_ disabling (lost-time) injury \_\_\_\_\_ employee or staff injury

\_\_\_\_\_ On duty, or \_\_\_\_\_ off duty \_\_\_\_\_ visitor injury

Occupation (if employee) \_\_\_\_\_ Age \_\_\_\_\_ Sex \_\_\_\_\_

Date of injury \_\_\_\_\_ time \_\_\_\_\_ a.m. p.m. Place occurred \_\_\_\_\_

## DESCRIPTION OF ACCIDENT

## ANSWER FOR ALL CASES

1. What did the injured person DO which caused the accident? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
2. What other person was involved? \_\_\_\_\_ What did that person do which contributed to the accident? \_\_\_\_\_  
 \_\_\_\_\_
3. Did defective equipment, furnishings or other unsafe CONDITION contribute to the accident? \_\_\_\_\_  
 What was wrong? \_\_\_\_\_  
 \_\_\_\_\_
4. What persons other than the injured saw the accident? Identify fully \_\_\_\_\_  
 \_\_\_\_\_

## PATIENT CASES ONLY

5. Condition of patient before the accident? (check) disoriented \_\_\_\_\_ senile \_\_\_\_\_ sedated \_\_\_\_\_  
 normal and alert \_\_\_\_\_ other condition? \_\_\_\_\_
6. Were bed rails present? \_\_\_\_\_ Were bed rails up? \_\_\_\_\_ down? \_\_\_\_\_
7. What is patient's statement as to causes of accident? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

SEE THE OTHER SIDE

Fig. 1a. Accident Report Form

*This form, prepared by the National Safety Council, provides a good method for recording information on each injury.*

## STAFF PHYSICIAN'S STATEMENT

8. State injuries or other result, if any, from this accident \_\_\_\_\_

9. How, if at all, did the results of this accident affect the patient's original condition? \_\_\_\_\_

10. What treatment was given for these injuries? \_\_\_\_\_

11. Patient examined: date \_\_\_\_\_ hour \_\_\_\_\_ a.m.  
p.m.

Signed \_\_\_\_\_ M.D. (Staff Physician)

Signed \_\_\_\_\_ M.D. (Attending Physician)

## CORRECTIVE ACTION TAKEN

12. What steps have been taken to prevent similar occurrences and what further recommendations are made? (Replace or repair equipment, instruct employee, control patient or other action?) \_\_\_\_\_

13. Follow-up dates (for Admin. or Safety Comm.) 1 \_\_\_\_\_ 2 \_\_\_\_\_ 3 \_\_\_\_\_

COMMENT: \_\_\_\_\_

## FOR ADMINISTRATIVE OFFICE USE

## Disabling Injury Classification

## For Cost Analysis (if desired)

_____ Temporary total disability	Compensation . . . . . \$ _____
_____ Permanent partial disability	Medical . . . . . \$ _____
_____ Started losing time (date) _____	Public Liability . . . . . \$ _____
_____ Returned to work (date) _____	Property loss . . . . . \$ _____
_____ Permanent total disability	Other ("sick time," etc.) \$ _____
_____ Fatality	TOTAL cost, this accident \$ _____

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Fig. 1b. Reverse of Accident Report Form

*The back of the form allows additional information to be recorded.*



are some of the procedures that management should carry out:

1. Integrate safety into the contract specifications for buildings and equipment by requiring that the contractor or vendor meet all state and local safety requirements. This approach provides a safe environment from the beginning.

2. Provide good lighting and proper ventilation.

3. Supply safety clothing, gloves, goggles, protective footwear, gas masks, and dust masks as required.

4. Remove all obstacles and impediments to the safe movement of men, trucks, or machines.

5. Repair damaged floors, broken steps, broken glass, and cracked walls and ceilings.

6. Replace worn or damaged tools.

7. Provide proper equipment for the hoisting and movement of heavy objects.

8. Install nonslip floors and stairs, particularly in pumping and treatment plants.

9. Provide strong and completely protective stair and guard rails around pits, open tanks, or elevated platforms.

10. Install guards for moving parts of machinery.

11. Replace worn electrical wiring and fixtures.

12. Remove debris, waste matter, and obsolete or useless equipment.

13. Provide storage facilities of proper construction and design for all types of supplies, tools, and materials kept on hand.

14. Provide adequate sheathing and bracing materials for water main and service line construction and repair work.

15. Provide first-aid facilities, including transportation, within convenient reach of all workers.

16. Maintain sanitary locker and washrooms.

Although a detailed study of this manual will reveal a number of additional specific protective steps which should be taken under various circumstances, the points just listed are among those most apt to be of concern in all plants, regardless of the equipment or treatment methods used.

Following a basic plant inspection, it is helpful to set up a specific program of repairs, replacements, rearrangements, and other changes which may be called for and to prepare a timetable of action dependent on urgency, as well as a budget of costs involved. To the superintendent who must get approval from a board or council for all but routine operating expenditures, such an organized program and budget have special value. They outline his needs, demonstrate the care with which he has appraised them, give the appropriating authority a specific sum to deal with, and show that the superintendent is serious about safety.

Similar benefits accrue to the safety director who must gain the approval of top management. In his case it would be wise, as a followup of his own inspection, to escort the system's principal executive on a tour, pointing out the things that require corrective attention. Such a step not only helps the top man visualize the extent of the work which should be done, but it also demonstrates to the employees that he is backing the efforts of the safety director.

### Employee Cooperation

From the moment accident records are set up and plant inspections conducted, employees, of course, know that management is taking an interest

in safety. The minute that something specific is done about eliminating a hazard, this awareness grows into a conviction that management is taking safety seriously. An elaborate program of speeches, announcements, or bulletins is not necessary to insure that personnel understand the attitude of management. This is true not only when dealing with a handful of men, but also when hundreds of employees are involved. To turn this knowledge into a constructive force, however, does require further steps, planned to make employees feel that a safety program is their affair quite as much as management's, that they have a part to play in making it successful, and that they will be the principal gainers if it limits accidents and prevents injuries.

There is a place, even in a very small system, for a certain amount of formalized presentation of the safety story. It is advisable to arrange a simple meeting with the men and tell them what the idea is. The logical time is immediately after the first examination of safety records. If known accidents or injuries have been listed, the talk can begin with a discussion of these. If there were none, a good way to draw out a small group is to ask the number of times its members have had narrow escapes on the job, directing the inquiry to each man individually.

Then the talk can be led around to the points covered in this manual, and the announcement made that there are to be detailed job-by-job inspections. Following these, a second meeting should be held, at which time a full report is made to the men regarding the hazards found. Everyone should be invited to make suggestions for improving conditions, and the superintendent should be ready to tell what

he plans to do about repairs, replacements, or safety devices and equipment.

In the small community, where everybody knows nearly everyone else, it pays to explain any budget items which may require town board or council appropriations. Each employee can be made a source of influence, spreading the story through his family and friends to reach, fairly quickly, the town officials. In turn, the feeling that he has helped will make each individual employee more interested in the safety program and its success. The next step in small systems is chiefly a matter of checking over the sections of the manual which apply to each man, analyzing his work methods with him, and making suggestions.

Even in a very small utility, it is desirable to have an occasional meeting with employees to obtain an exchange of views and experiences, to review the elimination of hazards, along with the emergence of any new ones, and to emphasize the importance of teamwork by the group. A rather formal safety inspection would precede these sessions, and it is on such occasions that inspections by outsiders might profitably be made. It is also helpful if, at least once a year, a safety man from the outside is brought in to sit down and talk things over at one of the meetings. It stimulates interest to assign individual employees to attend safety conferences that may be held by business firms, municipal departments, or associations. It may be possible, even in a small water department, to conduct safety contests with other organizations, either inside or outside of the framework of municipal service.

In larger organizations—those employing, say, fifteen or more workers—it is desirable to set up a safety committee composed of representatives of

the major areas of work, such as pumping, treatment, and distribution. In a system of this size, probably someone other than the superintendent is the safety director. The pattern of activity follows that suggested in smaller systems, with certain modifications. For example, although the superintendent or manager would preside at general meetings, the safety director would take over the conduct of discussions. A safety committee would probably meet at least once a month, or oftener, if required, while general employee meetings might be held only twice a year. Individual employees would be encouraged to make their suggestions and recommendations through the safety committee members rather than to the superintendent or safety director.

As more men are involved, and the physical extent of the system becomes more widespread, it is helpful to make use of posters, payroll envelopes with safety messages, safety leaflets, and printed or mimeographed digests of safe practices taken from the manual and similar material. Many insurance companies give these items for the asking or at very low cost, while local, regional, and industry-wide safety councils are also sources of supply. The AWWA cartoon character, "Willing Water," can easily be converted into a cheerful and effective safety propagandist. A rule to be observed, particularly with posters and bulletin board material, is that any item displayed loses impact after it has been seen too often. Provision should be made for periodic changes in postings if interest is to be kept alive.

In larger utilities, maintenance of the safety program places a heavy share of responsibility on supervisors and foremen. They have the obliga-

tion to watch for unsafe conditions and work practices, to report accidents and injuries, to enforce safety rules, and to instruct personnel in safe practices. In turn, the safety director must organize his efforts to channel training and inspection activities through the supervisory group. Regular safety meetings of supervisors should be scheduled. The programs should deal not only with the elimination of hazards and the principles of safety, but with the methods of teaching accident prevention to personnel.

It is helpful to prepare digests—taken from material in this manual—covering both general and departmental working practices. In addition to meetings, the safety director should work out a specialized instruction program with each department head. It is advisable to arrange for regularly scheduled safety sessions at the departmental level, to be conducted by the supervisors. The safety director, from time to time, sits in on these sessions, although conduct of the meeting should always rest with the supervisors. On such occasions, demonstrations of safe and unsafe methods could be given and opportunity provided for employees to raise questions or make suggestions.

Although emphasis must be placed on the departmental approach in large utilities, it is always important that all personnel are convinced that the program is a utility-wide undertaking. At the beginning, and at least semiannually thereafter, general meetings of all available employees should be held and attended by the top executives of the system. These gatherings should provide occasion for talks by the superintendent or general manager, showing the support behind the safety director and the interest taken in accident pre-

vention. Graphic presentations of the progress made in safety work reports on elimination of hazards, and an analysis of situations which require further effort should be given.

The principal problem in larger organizations is to overcome the sentiment that safety is just the supervisor's job and that the individual employee has no particular responsibility in preventing accidents. Formation of a joint committee including foremen and workers provides one device for drawing all employees into the program. Another approach calls for each supervisor to appoint a member of his department as safety man, rotating the appointments on a monthly or quar-

and other weeks devoted to safety measures

3. Safety quizzes that provide a basis for departmental competition

4. Safety skits and playlets to be performed by personnel

5. Showings of safety motion pictures and slides

6. Special drives with prizes for safety suggestions

7. Distribution of safety calendars

8. Use of safety material in the plant magazine or newspaper

9. Fire, disaster, and gas mask drills

10. First-aid classes.

Other suggestions will come to mind as the program gets under way. Safety training ties in naturally with



### Willing Water Says:

Knowing the causes of accidents is essential to preventing them.

terly basis. During his term of office, each man would be responsible for accident reports, safety inspections, posting of interesting material on the bulletin boards, and other procedures. He might also attend supervisors' safety sessions, handle some part of the departmental meetings, and go to community or regional safety conferences. Other good ideas which the safety director of a larger system can develop are:

1. Safety contests between departments or plants, with prizes or bonuses for the best records

2. Special campaigns, such as "No Accident Week," "Cleanup Week,"

the overall personnel training program, labor relations, and public relations. Everyone can find ways to make the safety program more interesting, livelier, and more effective.

### Control of Work Habits

Regardless of the degree of safety built into a job, unsafe actions on the part of human beings will always be a cause of injuries. Teaching employees good work habits means showing them how to do their task with less risk to themselves, less spoilage of materials, and less damage to equipment. Much of this instruction can be boiled down to a few simple principles or job rules.

By concentrating on these, by showing the "why," as well as the "how," and by supervising to check carelessness promptly, safe work habits can obtain acceptance of employees.

The material in this manual provides many suggestions covering both general work habits and those involved in specific departmental operations. A good way to start is to prepare brief digests of the general and departmental safe-practice recommendations as guides either for the men on the job or for the supervisors, depending on the size of the utility.

Such condensations should be used in conducting preliminary discussions and in on-the-job observation sessions. Where a faulty practice is noted, it is sound procedure first to ask the individual why he is doing the job in that particular way. This opens the door to the kind of give-and-take review which is more persuasive than a flat instruction to change a working method.

Wherever possible, actual demonstrations of right and wrong ways of doing tasks should be conducted, always accompanied by explanations of the basis for preferring one work habit to another. Insurance companies, safety councils, and equipment manufacturers often have safety displays available, with models, dummies, and graphic materials. Even a very small organization can arrange for such presentations from time to time.

Fully as important as the initial instruction is the watchful eye on subsequent performance. When the right way has been presented and agreed to by the individual worker, it is essential that failures to comply should be promptly noted. It may be desirable to insist that a certain step be repeated

or a job be redone, simply to emphasize the seriousness with which safety is being taken by management. Flagrant disregard of safety rules should be met with appropriate disciplinary action, including discharge if necessary. Few employees question a decision affecting a fellow worker if it is made clear that his actions have endangered not only himself but also all of those who worked with him.

Where the details of safety training must rest in the hands of supervisors or foremen, it is desirable that the safety director hold rehearsals covering the way in which instructions are to be given or proper work methods demonstrated. By having one supervisor act as the instructor and another as the worker, added interest is given to supervisors' safety meetings, providing better results at the departmental level. Where an unusual or infrequently performed job is to be undertaken, the safety rules that apply should be carefully reviewed with the worker or supervisor immediately responsible. The same procedure should be applied when new equipment or treatment chemicals are to be employed. Special warnings should be prominently displayed and close supervision exercised until a correct work pattern has been definitely established.

### **Safety of New Employees**

Few efforts are more rewarding than those taken in the selection and training of new employees. Care should be taken in hiring to check not only a man's experience—particularly as it applies to the work he will do—but also his accident record. It is unfortunately true that the man who has developed a bad accident record on a job is likely to chalk up a similar one

elsewhere. If an inexperienced man must be employed, every effort should be made to secure one sufficiently adaptable to respond to training. Pre-employment physical examinations are highly recommended. They protect both the employer and the employee, eliminating the possibility that a man may be hired for work beyond his physical capacities.

The utility's safety goals should be stressed during the first interview, and any tendency on the job candidate's part to treat them lightly should remove him from consideration. Once hired, he should be given a special safety talk either by the superintendent or the safety director. General safety rules should be reviewed with him, and he should be supplied with the special safety information applying to his particular job. It would be helpful to have this material in written form, so that after an interval is allowed for him to read and digest the information, he may be asked to explain it in his own words. This procedure serves as a check on his understanding of the rules set down, and provides an opportunity for him to ask questions.

Good housekeeping should be stressed. Although management may have provided a place for everything, it is the employee's obligation to keep everything in its place. When the new

man starts work, either an experienced employee, in a small organization, or the foreman, in a larger system, should explain the job in detail, stressing safety, pointing out possible hazards, and calling attention to the safety rules that apply. In a small utility, it is advisable for the superintendent to share in this initial step. After the demonstration, the worker should be asked to restate his instructions and then do the work in the presence of the superintendent or supervisor. For the first few days, the employee should be checked at frequent intervals, asked about any problems that have arisen, and reminded of the safety practices that have been adopted. Any tendency to overlook safety rules should bring a prompt and vigorous warning.

Safety thinking, planning, and training pay off, whether in the informal effort made by a small-system superintendent and his close-knit group of helpers or in a highly organized large-utility program, complete with safety director, committees, meetings, and contests. A practical program lies within the reach of everyone. Once the responsible head of any utility decides he wants to prevent accidents, the activities necessary to achieve this result can certainly be fitted into the pattern of the system's operations.



### Willing Water Says:

Accident prevention first demands the creation of safe working conditions.

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## Effect of Inflation on Water Rates

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—C. C. MacDonald—

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*A paper presented on Nov. 8, 1954, at the West Virginia Section Meeting, Huntington, W. Va., by C. C. MacDonald, Vice-Pres., West Virginia Water Service Co., Charleston, W. Va.*

**I**NFLATION is a monster with many heads: cut off one, and up sprouts another. It is a technical subject of great complexity, but everyone is familiar with it, owing to first-hand experience. The deterioration in the value of the dollar has increased everybody's living costs substantially.

After all of the major wars in which the United States participated, there have been periods of inflation. The present one, keyed to World War II, has lasted much longer than the previous times. After the War of 1812, inflation lasted about 3 years. The inflation springing from the Civil War also lasted approximately 3 years. The acute period of inflation after World War I commenced several months subsequent to the Armistice in 1918 and reached a peak in May 1920, after which prices dropped drastically. It can be seen that these periods were not long lasting. Prices rose rapidly, returning to a more normal pattern over a relatively short length of time. The long duration of the present inflation, begun in 1946, has forced many utilities, privately and municipally owned, to increase their rates. This is generally resorted to as a last measure by management, as it prefers to use reserves to tide it over short intervals of inflation rather than disturb the rate structure. Most utilities can weather a brief inflation without serious consequences. Reserves are limited, how-

ever, and rates of most well managed water works must be increased to provide proper income and capital for expansion during extended periods of inflation.

### Price Levels

After the close of World War I, the *Engineering News-Record* Construction Cost Index rose to 273.8 of the base period using 1913 as 100. This same index was 641.89 in October 1954, an increase of 541 per cent since 1913—that is, construction costs then were about 15.6 per cent of what they are today. Present utility operating and construction expenses are at a peak in the history of the United States, with no abatement in sight. There may be a leveling off some day, but people are now accustomed to a much higher standard of living requiring higher wages, which in turn increase prices. It is likely, therefore, that water works will have to gear themselves to the new price level plateau for a long time.

The major elements that affect rates are materials, labor, and taxes. The first includes power and fuel for pumping, chemicals for purification, cast-iron pipe and fittings, copper tubing, meters, and materials for new construction and maintenance. As the costs of these items increase, it is inevitable that rates must be raised to furnish satisfactory service and meet growth requirements. Proper services

cannot be provided at less than their cost of production.

Twenty years ago, the author's firm retained approximately 40 per cent of its revenue dollar for debt and equity charges, after paying all operating and maintenance expenses, including depreciation and taxes. Ten years later, 1943, that percentage had declined to 34. In 1948, the percentage was down to 29. Today, the amount retained has reached a low of 25 per cent. Since the end of World War II in 1945, there has been a tremendous growth in the systems, requiring the investment of substantial new capital at the prevailing inflated prices. Consequently, the rates have been increased for approximately 75 per cent of the customers, with other rises to come. The utility is also faced with the necessity of requesting a second increase for some of the plants where large capital investments have been made and net earnings have declined since the last rate change. Operating economies have been effected, but have been offset by the continued advance in the costs of materials and labor.

Most water works men are familiar with the history of cast-iron pipe prices. Twenty years ago, 6-in. and larger pipe averaged about \$37 a ton, excluding freight costs. Ten years later, 1944, the average was \$45 a ton. Starting in 1946, the price rose drastically to \$103 a ton at the present, an increase of approximately 180 per cent in 20 years. Copper tubing costs have increased more than 80 per cent during the past 10 years.

### **Rate Rises and Depreciation**

Inflation has also been a constant problem for the regulatory commissions in the various states. Increased operating and construction expenses,

coupled with rising interest rates, have forced many utilities to petition for higher rates. Their necessity varies with different companies. One that has invested large amounts of new capital during a time of high prices will have to pay for the added fixed costs, including interest on debt and higher depreciation charges. On the other hand, a static company will not be faced with these difficulties. Although recognizing the plight of utilities faced with large expansion programs during periods of rising prices, many regulatory commissions have not increased rates sufficiently to give a fair return. Rate fixing, a highly controversial procedure, ordinarily takes a considerable length of time from the date of application to the date of final settlement. This lag does not work to the best interest of an expanding utility.

Water works have the problem of high replacement costs. In West Virginia, the Public Service Commission allows depreciation based on original cost. Under this method, equipment installed years ago is depreciated on a low-price basis. When this property is replaced at present-day costs, the utility's investment is increased, as the depreciation reserve is not adequate. A fair return on the larger investment can only be accomplished by higher rates, but by the time the new ones are effective, the process has often repeated itself. It is the physical property that furnished the service—and not the original dollars invested—for which adequate depreciation reserves should be provided. The allowances must be sufficient to return the cost of the equipment worn out in service. Some utilities have advocated economic depreciation as a means of compensating for attrition of capital due to infla-

tion. Many regulatory bodies are currently considering the matter.

### Unwise Law

The high price level has worked a hardship on West Virginia utilities, which are required to make main extensions under Rule 22 of the Public Service Commission. This law was revised in 1954, but although it was liberalized a little, a water works cannot earn an adequate return on the investment it is required to make at present-day prices. Under the revised rule, utilities must extend mains free of cost for a distance of 50 ft for each customer. On any extension exceeding 50 ft, up to 120 ft per customer, a privately owned utility is allowed a surcharge of 13 per cent per annum on the cost of the extension over 50 ft. The surcharge for municipally owned works is 11 per cent. Experience has shown that an adequate return requires a surcharge of not less than 20 per cent. Therefore, extensions made under Rule 22 lower the overall return of the utility, which is eventually compelled to seek higher rates for the entire system.

The Charleston, W.Va., system, serving the Kanawha Valley area, had its rates unchanged from 1920 to 1951. During that period, the prosperity of the 1920's vanished in the depression of the 1930's. World War II took place, and the present inflationary era was born. After the end of the war, additional revenue derived from the growth in the Kanawha Valley, along with operating economies effected, tended to diminish the full force of inflated prices sufficiently to postpone the adjustment of rates. The unabated upward trend of prices finally reduced the earnings to a point where it was necessary to petition for relief.

Water is sold at such a low price, relatively, that water company officials and managers of municipal plants should not hesitate to apply for higher rates where they can be justified. These people have an obligation to their customers to maintain good service and meet expansion requirements. When it is realized how prices have risen for such things as food, clothing, rents, transportation, and amusements, an increase in water rates which may average a few cents a day per customer is negligible. The West Virginia Water Service Co.'s residential accounts for 1953 averaged \$31.15 per customer, compared with an average of \$25.12 in 1948. That is an increase of 24 per cent, but is only 1.6 cents a day. The rise for commercial accounts was only 10 per cent, or 2.9 cents per day. These figures cover the 5-year period (1948-53) during which higher rates were made effective for 73 per cent of the customers.

### Conclusion

Rates should be reviewed periodically and adjusted whenever the income needs of a system are jeopardized. Inflated prices eventually raise all living costs, so that the water industry, which has done a fine job over many years, is certainly entitled to an increase where earnings have been seriously hurt. Any delay in petitioning for higher charges augments the injury, as lost earnings cannot be recouped in the future.

Water rates have contributed little to the forces of inflation that have been rampant for many years, but to the contrary, inflation has been the principal cause for the increase in many water rates.

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## Elements in Sizing Water Mains

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A. T. Luce

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*A paper presented on Sep. 9, 1954, at the New York Section Meeting, Montauk, N.Y., by A. T. Luce, Vice-Pres., New York Water Service Corp., New York, N.Y.*

**S**IZING water mains may seem to be rather simple, but it is actually about the most complex of all the problems faced by the water works operator. Because the distribution system of the average water works plant represents the largest item of cost, it is apparent that planning the sizes of the various lines is very important. Unfortunately, few water works men have had the opportunity to lay out the complete water plant and thus been able really to plan and construct the distribution system according to the best balanced design. Even if present-day operators had been able to plan their systems completely many years ago, some of their prophecies about the location and amount of growth would have differed quite radically from what actually occurred. Today, personnel must decide on the best plan for tying new main extensions into existing works. Water mains are expensive, long-lived structures, and the average growing community has difficulty in financing any but the most urgent extensions. Therefore, one must be as sure as possible that what is proposed is correct both economically and hydraulically.

Few plants have a well prepared study of or program for future growth which they can follow with only occasional revisions to bring it in line with actual growth. Such a long-range

plan, which can be developed by the superintendent, is highly desirable, especially in the selection and location of arterial mains.

### Pumpage and Population Chart

Make a chart with the vertical lines representing years (starting with the year the plant was built and extending, say, to 1975) and the horizontal lines representing population and pumpage. Plot the average daily pumpage, the maximum daily pumpage, and the population, year by year. Thus, there will be three growth curves on the chart. The chamber of commerce, builders, bankers, and others should be interviewed to determine their views about the future growth of the community over the next 20 years—or as far ahead as they will hazard a guess. These data will serve to extend the population growth curve on the chart to 1970 or 1975.

From the average production or water use figures for a number of years back, deduct the quantity used by large industrial consumers (such as factories or railroads) which take a practically constant amount from year to year; then develop an estimate of the growing industrial water demand.

Next, separate the quantity used by domestic consumers, small shops, filling stations, and similar commercial enterprises. After carefully estimating

the number of consumers, develop the average yearly per capita daily use. The latter figure, multiplied by the estimated growth in population gives the projected increase in average daily domestic consumption. Consult the industrial plants to obtain any anticipated future increases in water use, and reduce the total of these figures to gallons per day. To project the average daily consumption curve, add the annual increase in domestic and industrial use to the current figure, after making such other adjustments as are desirable.

Look back over the records for several years and determine the maximum day of each year. If possible, compute the actual use by taking into account not only the water produced, but also the gain or loss in storage in the distribution system reservoirs or tanks.

It is highly important each summer to note if a certain day appears to be developing into a record one for the year. If so, keep a more detailed record of hourly rates, both into the system from the plant, and in and out of storage. In addition, take pressure readings on hydrants at critical spots in the distribution system, noting not only the pressure but also the time. At his convenience, the operator can take the pumpage charts, reservoir level records, and tank and hydrant pressure information and work out the hourly use and system deficiencies. These data are of enough importance to warrant taking a number of employees away from some regular duties in order to obtain the extra readings. Peak days are the critical points in design preparation, and every effort should be made to determine the full story of just what happened every hour of the record day. Of course, it cannot be predetermined just what

day will be the peak, so if another heavy-consumption period arrives, data should also be gathered on it. Information on peak days enable the operator to project fairly well what would occur upon another day when the use was a little higher. The maximum-day data are also used in projecting the maximum days of the future, by applying the proper population ratio to the domestic consumption.

### Distribution Map

Secure a map of the community and the adjacent area that may be developed within the next 20 years; lay out the present distribution system, including source of supply, reservoirs, and tanks. The next step is to consider the direction in which growth is going to occur and to plan accordingly. The units of per capita consumption previously developed will aid in arriving at the quantities of water that will be required in the various areas. If the land is zoned, this would be a material aid. The density of suburban houses in the vicinity can be obtained from existing developments and zoning regulations. In many cases, this runs about five houses per acre, so that one might use 20-25 as the population per acre figure.

Another point to be considered is that new houses in recently developed areas generally use more water than old homes for the first few years. This is due to the fact that lawns and plantings are being established, and that most of the new suburban houses are occupied by young people who are raising families. This condition has a very marked effect on communities where a great many homes have recently been built and where such growth is continuing.

Having established the basic data, the problem of analyzing the existing distribution system and planning future extensions may then be worked on. No two communities are the same: the topography is different, and though basic data may be similar to that of nearby water works, it is not the same in all respects.

### General Distribution Design

In the general design of a distribution system there are three types of mains:

1. *Primary feeders.* Sometimes called arterial mains, these form the skeleton of the system.

2. *Secondary feeders.* These carry great quantities of water from the primary mains to the various areas for supply and fire flow.

3. *Small distribution mains.* These form a grid in the various areas and serve the individual fire hydrants and consumers.

The primary feeders should be so located in the distribution system that they will carry large quantities of water between the plant, the storage facilities, and the various parts of the service area. In small systems these mains should form a loop, extending around the territory served and generally traversing streets about two-thirds of the way out from the center of town. This arrangement will permit secondary circuits outside and inside of the primary loop. The primary feeders should be valved at least every mile, and all mains connecting to them should have valves so that interruption of service in any of the distribution mains will not require shutting down the primary feeder main. Looping permits continuity of service through the balance of the primary feeder main

if one section should be shut off temporarily, and under normal operations also allows water to be brought from two directions for heavy fire flows. An interruption near the plant in a single feeder main would cut off the entire community. Computations have shown that distribution systems designed with this loop feeder located as described are more economical than those with a single feeder up the center or a loop around the outside. In larger communities these primary feeders may be constructed as several interlocking loops as they should not be located more than 3,000–4,000 ft apart.

The secondary feeders form smaller loops within the loops of primary mains or outside, on the edge of the community. These should be only a few blocks apart and of sufficient size to serve the areas properly. The distribution mains usually have their size determined by fire flow requirements. Generally speaking, these call for mains of diameters not less than 6 in. and with no dead ends, if possible. If the system abuts a stream or other barrier, it may be permissible to use smaller size mains for short stretches or between larger mains, bearing in mind that the zone for fire protection purposes is 500 ft from the nearest hydrant. The requirements of the National Board of Fire Underwriters (1) plays such an important part in the insurance rates established for each community that it is of great importance for the water works operator to take note of its schedules upon laying out the water system.

The matter of pressure must also be given consideration. It has been found that 25–40 psi will give satisfactory service in areas occupied by one-story houses, although the height of buildings in the business district necessitates con-

siderably more pressure. Specific pressure requirements will have to be determined for the particular community, as will residential needs, because the arrangement of the existing water system, topography, and character of the service set the local requirements. The higher the pressure in the system the greater the leakage and the higher the pumping cost; therefore, it is necessary first to establish minimum pressures for the various areas. The economic balance between installing large size mains and paying for power to pump at higher heads may then be determined. Although the average consumption is generally assumed to be 140 gpcd and the maximum day anywhere from 120 to 850 per cent of the average day, the individual water works man has presumably gathered reliable figures for his average day, maximum day, and maximum hour. As stated before, the design should be based on the maximum day and should also be able to take care of the fire demand.

### Hazen-Williams Formula

There are a number of formulas for computing the size and carrying capacities of water mains, but the one most frequently used is the Hazen-Williams formula. From it, tables that should be in every utility's file have been developed. Under its procedure, a factor called  $C$  is used to denote the coefficient of friction. The value of  $C$  of new cast-iron pipe is probably about 130, but after years of use and the tuberculating effects of some waters, it may drop to half, indicating that the carrying capacity is reduced by half. To be safe, many designers use a  $C$  of 100, which allows some margin. The value of  $C$  for cement-lined cast-

iron, concrete, or asbestos-cement pipe in the smaller sizes will tend to stay at the higher figure of 130-140 for many years. It should also be borne in mind that the difference in cost between adjacent sizes of small mains, such as 6 in. and 8 in., lies almost entirely in the cost of the pipe itself, as the trenching and backfilling requirements are practically the same, and that the carrying capacity of the 8-in. pipe is twice that of the 6-in. In computing the flows in the pipe system, it is necessary to determine the quantity of takeoffs from the principal mains at various points and to resort to the use of one or more of the generally known methods of computing the hydraulic grade line through the system. It will be necessary to decrease the sizes of some pipe if, on the first try, the size selected results in a hydraulic grade line that is too high. Conversely, the pipe size must be increased if the grade is too low. The balancing of flows through a network of pipes requires experience and judgment, and one should not expect to get the perfect solution on the first few tries. The Hazen-Williams hydraulic tables and slide rule will prove helpful.

There are at least five methods of solving the network problems: [1] uncontrolled trial and error; [2] Freeman graphic method; [3] Hardy Cross method; [4] electric-network analyzer; and [5] hydraulic-model method.

In the first three methods, trials are made. In the fourth the problem is solved by inserting resistances in an electrical circuit representing the pipe network. In the last method, a model is made. There are a number of good handbooks which give the details of the first three methods (2, 3).

### Distribution Plan

The location of the primary and secondary feeders may be roughly plotted, after which the next step is to determine their size. Then the quantity required for each of the smaller distribution areas must be computed from the maximum daily consumption, and the takeoffs from the secondary feeders plotted. By use of a map, the length of each section of the secondary feeders between the takeoff points back to where each joins the primary feeder can be measured. A tabulation showing the distance between distribution takeoffs and the daily quantity at each takeoff should be made. From this, the proper size of the secondary mains can be determined. In a similar manner, the connections of the secondary feeders to the primary feeders are noted, the takeoff quantities and distances tabulated, and the sizes of the primary mains computed.

The figures on hand must be balanced to reflect the proper relationship of the quantities required for the various secondary-feeder takeoffs, to meet the hydraulic grade of the primary feeders. This is done if too much or too little has been allocated to each end of the secondary connection. As

this is a trial-and-error procedure, one should not become discouraged if the first attempt does not develop the proper hydraulic grade line. After figuring the maximum load through the system, it would be well to make a few checks by adding substantial fire flows at critical points, to be sure that the flows will be carried.

As has been shown, the selection of the proper size of mains is not an easy matter: there is no simple, hard-and-fast rule that can be followed, because each situation has its own set of conditions. It is most important, however, that primary and secondary mains be provided for at regular intervals throughout the system and that these be adequate to carry the additional water for suburban extensions anticipated in the near future.

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## Chemical Reactions in Hot and Cold Treatment Units

V. J. Calise, J. Duff, and R. Dvorin

*A contribution to the Journal by V. J. Calise, J. Duff, and R. Dvorin,  
all from the Graver Water Conditioning Co., New York, N.Y.*

**H**OT and cold softeners are chemical reaction units which treat water with chemicals at various temperatures to reduce dissolved and suspended impurities. The hot-process apparatus, extremely versatile, is capable of treating waters of wide ranges of composition to produce an effluent meeting present-day requirements for minimum concentrations of hardness, silica, oxygen, alkalinity and dissolved solids in feedwater. The hot-process unit is not subject to the limitations imposed by the effect of cold water temperatures on chemical equilibriums, reaction rates, and compound solubilities.

Operating results at hundreds of large-scale installations of hot- and cold-process units have demonstrated the effectiveness of higher temperature, proper excesses of chemicals, and contact with preformed solids or sludge in accelerating chemical reactions (1, 2, 3, 4). Also, results obtained by cold-process softeners from waters containing large proportions of various anions indicated differences in reaction rates which could not be explained solely on the basis of differences in plant conditions. In order to verify such large-scale results, as well as to study the various factors influencing the chemical reactions, from a practical operating point of view, a series of laboratory investigations was made,

employing modern techniques and latest methods of analysis.

The factors studied were:

1. Effect of type of anion and preformed precipitates on rate of reaction of  $\text{CaCO}_3$  and on residual-calcium hardness concentration.
2. Effect of temperature and excess of chemical on chemical reaction rate and on residual calcium hardness concentration.
3. Effect of varying concentrations of preformed precipitates (sludge) on rate of chemical reaction of  $\text{CaCO}_3$  at  $80^\circ\text{F}$ .
4. Effect of varying concentrations of preformed precipitates (sludge) on rate of chemical reaction of  $\text{CaCO}_3$  at  $212^\circ\text{F}$ .
5. Effect of temperature on silica removal by freshly precipitated  $\text{Mg}(\text{OH})_2$  and accumulated  $\text{MgO}$  compounds.
6. Effect of concentration of accumulated  $\text{MgO}$  compounds on silica reduction.

### Effect of Type of Anion and Preformed Precipitates

The laboratory data compiled in a series of tests are presented in Fig. 1. The results show that at  $80.5^\circ\text{F}$  the type of anion initially present in the raw water has a significant effect on the rate at which insoluble calcium carbonate is produced when no pre-

formed precipitate is present. The sulfate anion,  $\text{SO}_4^{--}$ , seems to have the greatest effect on slowing the rate of reaction and formation of  $\text{CaCO}_3$ . The chloride anion,  $\text{Cl}^-$ , seems to have less slowing effect; and with virtually no anions in solution except  $\text{CO}_3^{--}$ , the rate of reaction on formation of  $\text{CaCO}_3$  is greatest, of course, when lime is added to  $\text{Ca}(\text{HCO}_3)_2$  in solution. When 1,000 ppm insoluble  $\text{CaCO}_3$  is

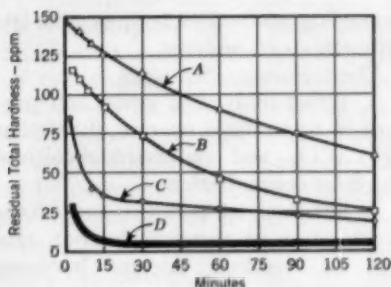


Fig. 1. Effect of Anions and Preformed Precipitates on Rate of Reaction

The temperature is 80.5°F. All hardness is calculated as  $\text{CaCO}_3$ . A—230 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaSO}_4$ ; B—230 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$ ; C—200 ppm  $\text{Ca}(\text{OH})_2 + 30$  ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{Ca}(\text{HCO}_3)_2$ ; D—combined curve for three tests made under the same conditions as A, B, and C, except that 1,000 ppm insoluble  $\text{CaCO}_3$  was added.

present at 80.5°F, however, all three chemical reactions take place at roughly the same rapid speed. These are substantially completed in less than 15 min in the presence of preformed  $\text{CaCO}_3$  sludge. Furthermore, a very much lower residual-calcium concentration is obtained than could be produced by several hours of reaction without sludge solids.

The data presented serve to emphasize the importance of designing cold-

process equipment to provide maximum contact with solid sludge particles in order to accelerate the calcium carbonate chemical reaction as well as to obtain as low a residual-calcium hardness as possible. The slowing effect—observed mainly with cold-process units—of certain anions and colloidal organic materials has been overcome in practice by mixing the raw water and chemicals with concentrations of sludge

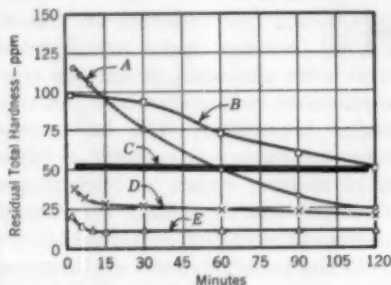


Fig. 2. Effect of Temperature and Excess of Chemical on Chemical Reaction Rate

No preformed precipitates have been added. All hardness is calculated as  $\text{CaCO}_3$ . A—230 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$  at 80°F; B—200 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$  at 80°F; C—170 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$  at 212°F (three tests); D—200 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$  at 212°F; E—230 ppm  $\text{Na}_2\text{CO}_3$  added to 200 ppm  $\text{CaCl}_2$  at 212°F.

exceeding 0.1 per cent by weight or 1,000 ppm. Practical experience in hot-process treatment has shown temperature is the most important factor in speeding up chemical reactions (4).

#### Effect of Chemical Excesses and Temperature

Figure 2 shows graphically the results of tests made with calcium chloride in the absence of preformed precipitates. The data clearly indicate

that at 80°F an excess of  $\text{CO}_3^{--}$  is necessary to speed up the chemical reaction rate as well as to reduce residual-calcium hardness to as low a value as possible. At 212°F the rate of reaction is not markedly affected by excess of chemical, but a somewhat lower residual-calcium hardness is obtained.

It is quite important to maintain suitable excesses of chemicals in the cold-process treatment. Where heavy concentrations of solid sludge particles are present, however, practical experience indicates that chemical reactions are markedly speeded up, and lowest equilibrium residual-calcium hardness concentrations are obtained rapidly (5).

Operating experience confirms that at high temperatures the rate of calcium carbonate reaction is not affected by chemical excess, although, of course, the equilibrium residual concentration of calcium is in a virtually direct relationship to the amount of chemical added.

### Effect of Varying Concentration of Preformed Precipitates

The data presented graphically in Fig. 3 clearly show the remarkable effect of preformed precipitates (sludge) in accelerating at 80°F the chemical reaction forming  $\text{CaCO}_3$ . Residual concentrations of less than 6 ppm calcium hardness were found about 15 min after addition of soda ash, when 1,000 ppm  $\text{CaCO}_3$  suspended solids were present.

Interestingly enough, as the concentration of suspended, solid  $\text{CaCO}_3$  was increased to 10,000 and 50,000 ppm (as  $\text{CaCO}_3$ ), the residual-calcium hardness increased to approximately 10 and 15 ppm, respectively. The data shown in Fig. 3 indicate that the higher concentrations of solid precipitates at

10,000 and 50,000 ppm permit somewhat more rapid reaction (under 3 min) than with 1,000 ppm solids.

These figures emphasize again the importance of having the raw water and chemicals come into contact with fairly high concentrations of suspended solids immediately on entrance into cold-process treatment units (6, 7). This is to be followed by flocculation, settling, and separation of clear, treated water from the solids, as obtained in a conventional high-rate solids-contact ("upflow") unit (see Fig. 4 and 5).

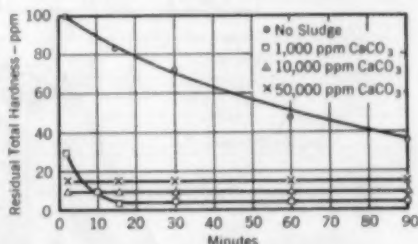


Fig. 3. Effect of Varying Concentration of Preformed Precipitates (Sludge) on Rate of Chemical Reaction at 80°F

The tests were made by adding 230 ppm  $\text{Na}_2\text{CO}_3$  to water containing 200 ppm  $\text{CaCl}_2$  only. All hardness was calculated as  $\text{CaCO}_3$ .

Tests were run at 212°F with no sludge, and 1,000, 10,000 and 50,000 ppm of suspended, solid  $\text{CaCO}_3$  flour. Figure 6 presents the results graphically, and Fig. 7 shows the laboratory setup. Contrary to cold-process experience (as shown in Fig. 3) the chemical reactions were complete in less than 10 min, regardless of whether sludge solids were present or not. This shows the extremely important effect of temperature in accelerating reactions, probably due principally to the increased mobility of the ions and

the reduced viscosity of the water (0.27 centipoise at 212°F and 0.93 centipoise at 80°F).

The concentrations of sludge solids (as  $\text{CaCO}_3$ ) above 1,000 ppm increase the residual calcium hardness from 10 ppm to 13 ppm. Their presence at 212°F does provide some increase in reaction rate in the range of less than

Another very interesting result of the tests is that the average residual-calcium hardness is higher at 212°F than at 80°F (10–12 ppm as against 6 ppm), with the same reaction and excesses of chemicals. This indicates that at higher temperatures calcium carbonate has increased solubility, contrary to previously reported data. The

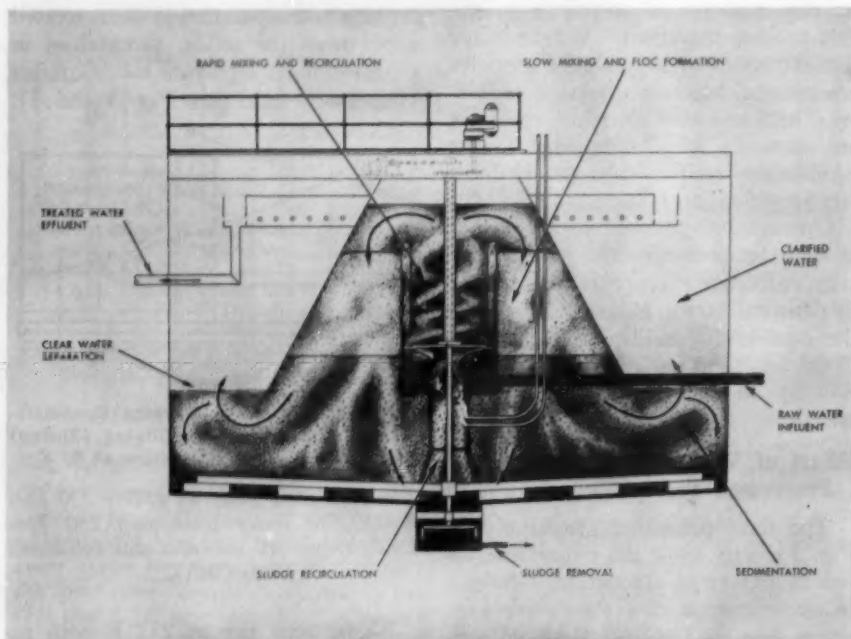


Fig. 4. Reactivator Solids-Contact Unit

The apparatus depicted is a product of the Graver Water Conditioning Co., New York.

10 min. For example, in 2 min, without any sludge solids present, residual-calcium hardness is 20 ppm; with 1,000 ppm sludge solids, in 2 min the residual-calcium hardness is 10 ppm. In contrast, at 80°F without sludge solids, residual-calcium hardness is 100 ppm in 2 min; with 1,000 ppm solids, the residual-calcium hardness is 30 ppm.

authors can offer no explanation for the contradiction.

#### Effect of Temperature on Silica Removal

Fig. 8 shows graphically the results obtained in a series of tests with freshly precipitated  $\text{Mg}(\text{OH})_2$ . At various temperatures, 170 ppm NaOH was added to 150 ppm  $\text{MgCl}_2$  with approxi-

mately 15 ppm  $\text{SiO}_2$  present, resulting in pH 10.8. Portions of the solution were withdrawn at various intervals, filtered, and analyzed for  $\text{SiO}_2$ , employing acid-molybdate and a Klett Summerson colorimeter.\* Precipitation of  $\text{Mg}(\text{OH})_2$  *in situ* was felt to eliminate the necessity (if MgO were used) for considering rates of hydration.

The profound effect of temperature upon the rate of reaction is shown in Fig. 8. Where adsorptions would be

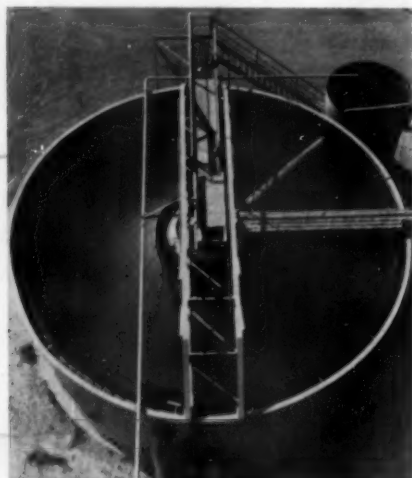


Fig. 5. Solids-Contact Unit

*This typical installation is in use at a municipal water softening plant.*

greatest—at the lowest temperature, 40°F—the residual silica initially drops to approximately 13 ppm and then slowly decreases with time. As temperature is increased, the initial drop and subsequent reduction and reaction with silica is greater and more rapid. This behavior is the very opposite of normal adsorption reactions occurring at optimum efficiency with lower temperatures (8).

\* A product of Klett Mfg. Co., New York.

On the basis of these data and those shown with accumulated MgO compounds in Fig. 9, it is postulated that the silica is removed from solution, in sequence, by the following process:

1. If MgO is initially employed, it is first hydrated to form the hydroxide  $\text{Mg}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ . With  $\text{Mg}(\text{OH})_2 \cdot x\text{H}_2\text{O}$  formed by precipitation *in situ*, hydration is virtually instantaneous; hydration of MgO occurs faster at higher temperatures.

2.  $\text{SiO}_2$  is adsorbed upon the  $\text{Mg}(\text{OH})_2 \cdot x\text{H}_2\text{O}$  particle.

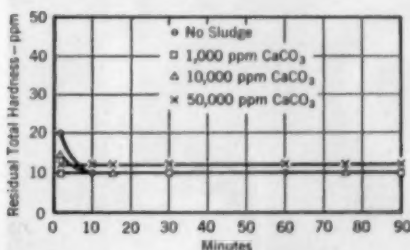


Fig. 6. Effect of Varying Concentration of Preformed Precipitates (Sludge) on Rate of Chemical Reaction at 212°F

*The tests were made by adding 230 ppm  $\text{Na}_2\text{CO}_3$  to water containing 200 ppm  $\text{CaCl}_2$  only. All hardness was calculated as  $\text{CaCO}_3$ .*

3. Inward diffusion of the  $\text{SiO}_2$  and desorption of the  $\text{Mg}(\text{OH})_2 \cdot x\text{H}_2\text{O}$  takes place.

4. Full formation of an insoluble magnesium silicate compound occurs. Both steps 3 and 4 occur at a greater speed with higher reaction temperature.

The visual observations made in the course of the tests indicated that the precipitate formed at 40°F was present only as a very fine turbidity. At 190°F, however, a very heavy floc was formed. It is assumed that the adsorption capacity of the finely divided floc is substantially greater than that of the

heavy, aged floc. Nevertheless, the rapid adsorption reaction is responsible for a silica decrease, of minor importance—approximately 2 ppm.

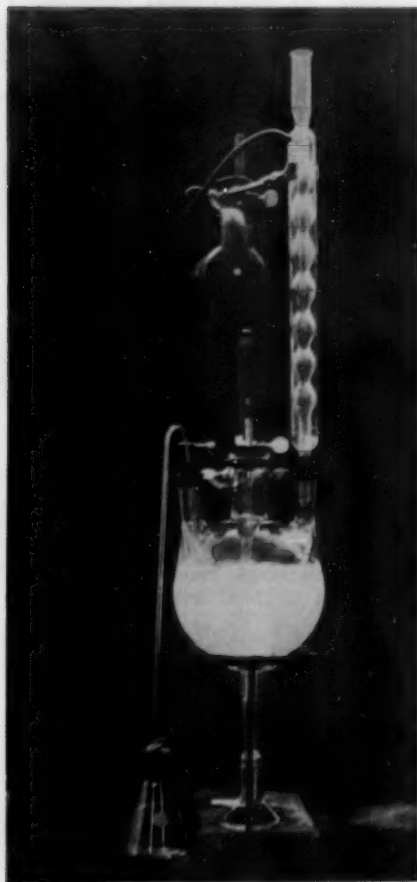


Fig. 7. Laboratory Setup

This apparatus was used to run all the tests made at 212°F.

The laboratory data substantiate the operating results from large-scale installations. Where magnesium oxide compounds (precipitated *in situ*) of various activations and degrees of hydration have been employed in cold-

and hot-process plants,  $Mg(OH)_2$  precipitated *in situ* seems to provide the greatest silica reduction for the quantity of magnesium precipitated. Nevertheless, hot-process plant operating data indicates very little difference in silica removal capacity between various types of MgO compounds at elevated temperatures.

In cold-process applications, specially activated, hydrated, and light-burned MgO compounds seem to provide optimum silica reduction because of their more rapid hydration at lower temperatures. Figure 9 shows the reduction obtained at pH 10–10.5 with

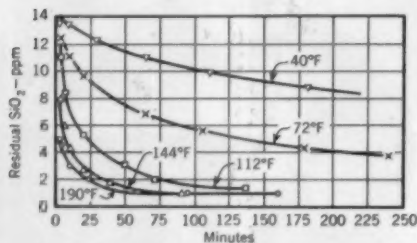


Fig. 8. Reaction Between Freshly Precipitated  $Mg(OH)_2$  and  $SiO_2$

There was 125 ppm  $Mg(OH)_2$  (as  $CaCO_3$ ) precipitated *in situ*.

accumulated MgO compounds at 68°F and 208°F. No ionic  $Mg^{++}$  was precipitated. Here again, with the same chemical dosages and accumulated MgO concentration, more rapid silica reduction is obtained at higher temperatures than at lower. These data tend to confirm the conclusions about the mechanism of silica reduction.

#### Effect of Contact with Solid MgO Compounds on Silica Reduction

The curves and data of Fig. 10 clearly show the effect of higher concentrations of MgO compounds in decreasing makeup MgO dosages and reducing silica to the lowest amounts in

the shortest time (1). In contrast, the effectiveness of silica reduction by contact with magnesium hydrate compounds is directly related to the concentration of magnesium hydrate precipitates brought into contact with the water being treated. For minimum magnesium oxide makeup, it is desirable to maintain the highest possible concentration of solid magnesium hydrate compounds (usually above 200

ppm) and practically. The high magnesium oxide makeup requirements of 200–600 ppm are calculated as MgO.

2. By contact with a deep, highly concentrated, dense bed or blanket of accumulated solids in a zone comprising the bottom cone and 1 or 2 ft of the height above the bottom of the straight section of the tank (see Fig. 11, right). In practice, with large

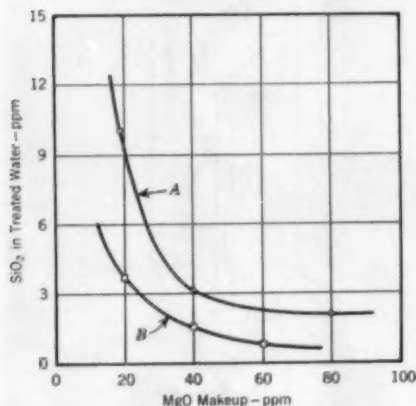


Fig. 9. Effect of Temperature on Silica Removal

A—temperature of 68°F, 4,000 ppm accumulated MgO added; B—temperature of 208°F, 4,000 ppm MgO added. A 30-min sludge agitation was followed by settling. The raw water contained 18 ppm SiO<sub>2</sub>.

ppm MgO) in contact with the water. In actual practice, this is achieved by two methods:

1. By recirculation of accumulated solids containing magnesium hydrate precipitate in the bottom cone through a pump into the top inlet of the softener, where chemicals, makeup MgO, and heated raw water also enter the unit (see Fig. 11 left). Thus, the magnesium hydrates are obtained eco-

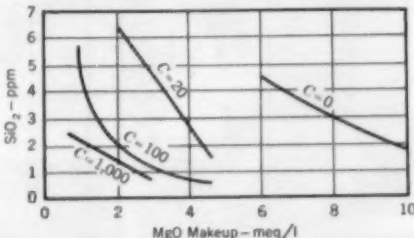


Fig. 10. Effect of Contact With Accumulated Magnesium Compounds at Boiling Temperatures

C—sludge magnesium concentration in meq/l (milliequivalents per liter). Material used as makeup and accumulated as sludge was a commercial calcined magnesite about 300 mesh. The raw water contained 15 ppm SiO<sub>2</sub>; temperature at 95°C; 20-min agitation of sludge; filtered effluent at pH 10–10.3; HCO<sub>3</sub> and CO<sub>3</sub> first neutralized with lime to prevent any of the Mg from passing through ionic stage; no ionic Mg precipitated.

downcomer units, a deep sludge bed provides concentrations of 3,000–8,000 ppm solid magnesium hydrate precipitates for 10–20 min reaction time. Very effective, low-cost silica removal is thus obtained with very small quantities of makeup MgO. Silica concentrations below 1 ppm are obtained in the effluent from large units employing a minimum of makeup MgO compounds with influent concentrations as high as 50 ppm silica.

The data in Fig. 10 substantiate practical experience showing that contact with MgO compounds in a deep, highly concentrated sludge bed is far more effective than sludge recirculation in reducing silica and makeup

alized makeup per 2 liters of calcium chloride solution. The necessity of adding such large amounts of makeup and the possibility that CO<sub>2</sub> from the air would form bicarbonate required the use of a closed system. The appa-

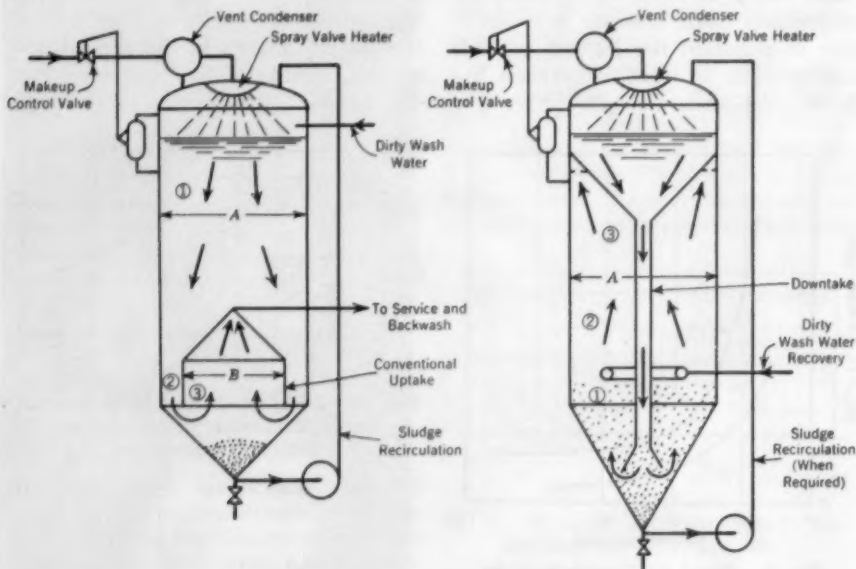


Fig. 11. Hot-Process Softeners

Both designs have the same outer tank diameter (A) or area. Left: conventional (uptake cone) units; settling area B is approximately 65 per cent of area A; velocity at point 3 is more than double that at point 1, because of weir effect; the critical separation velocity at point 3 is usually more than 4-6 gpm per square foot at rated load; settling time in uptake cone is less than 25 per cent of the total retention time. Right: type S (downcomer) units; the settling area surrounding the uptake is 90-95 per cent of the full area A; upward velocities at points 1, 2, and 3 are the same, permitting complete separation of any fine turbidity remaining after contact with sludge bed; at these points the critical separation velocity is less than 2-3 gpm per square foot at rated load; the settling time after leaving the downtake is more than 60 per cent of the total retention time.

MgO dosages (9). A typical large hot-process softener installation is shown in Fig. 12.

#### Test Conditions

*Hot.* The first three runs were at 212°F, requiring 2-4 liters of deminer-

ratus consisted of a 3-liter, three-neck flask with a reflux condenser, airtight stirrer seal, and siphon sample line. Direct heat was supplied by a burner at a rate sufficient to permit condensation at about three-fourths of the condenser. Agitation was provided to keep the

precipitates evenly dispersed throughout the mixture.

Sampling was done through the siphon. Some flashing in the line took place during sampling, but did not usually break the siphon. Specimens were filtered through Whatman No. 42 filter paper, then were sealed and cooled to room temperature in a water bath before analysis.

1. Measure out 2 liters of 200 ppm  $\text{CaCl}_2$  (as  $\text{CaCO}_3$ ) solution.

2. Add proper weight of cp calcium carbonate (precipitated powder).

3. Stir (boil 5 min in a hot test).

4. Add proper volume of 0.460N sodium carbonate solution and start timing.

5. Draw sample and filter. (Cool if in a hot test.) Determine the phe-

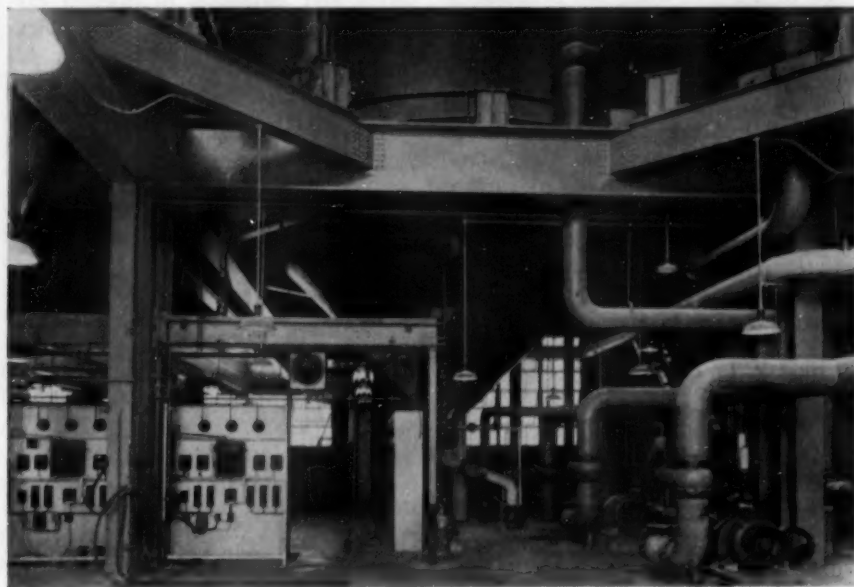


Fig. 12. Large Hot-Process Softener

*This typical installation is in use at a midwestern refinery.*

**Cold.** Several runs were in open beakers at 68–81°F. Fairly consistent increases in bicarbonates led to the use of apparatus such as used in the hot tests. The only variation was the substitution of a  $\text{CO}_2$  removal tube in place of a condenser.

#### Test Procedure and Observations

The general procedure used in both hot and cold runs may be outlined as follows:

nolphthalein and methyl orange alkalinity of a 25-ml sample.

7. Determine total hardness of a 25-ml sample with a microburet by the EDTA \* method.

**Accuracy.** Some experimental error is likely in the determination of alkalinity and total hardness. A buret can be read to an accuracy of 0.05 ml, so in 25-ml samples the error is  $\pm 2.0$  ppm. The data as gathered and tabu-

\* Compleximetric titration method.

lated, however, indicate that the overall error may be somewhat less than anticipated.

**Reagents.** Anhydrous calcium chloride of reagent grade was used for the 200-ppm  $\text{CaCl}_2$  solution. The calcium carbonate used as recirculated sludge was precipitated powder of reagent grade.

When no recirculated sludge was used in the cold tests, the precipitates tended to adhere to the glass, both stirrer and flask, and had to be scrubbed off. This effect was noted in the hot tests to a lesser extent, but was virtually absent when recirculated sludge was used. In both hot and cold runs, with and without recirculated sludge, the precipitates were very fine. The exception was with 0.1 per cent recirculated sludge, both hot and cold, where the precipitates were definitely flocculent. The lowest hardness values were obtained using a sludge concentration of 0.1 per cent.

### Conclusions

1. In simple chemical precipitation reactions involved in lime or soda ash softening at cold water or room temperatures, the presence of substantial amounts of solid precipitates or seed, such as  $\text{CaCO}_3$  flour, substantially speeds up the process.

2. At higher temperatures, the presence of seed influences the speed of the reactions less and less until, at temperatures above  $212^\circ\text{F}$ , little or no effect is had on the velocity of chemical softening reactions.

3. At room or cold water temperatures, silica removal by contact with suspended solid magnesium compounds is a sluggish reaction, even when magnesium is precipitated *in situ*.

4. At elevated temperatures, silica removal is most rapidly and economically effected by contact with large

concentrations of accumulated magnesium compounds. As this reaction occurs more rapidly at higher temperatures, apparently the silica removal is, initially, an adsorption process followed by an actual compound formation (possibly some type of magnesium silicate).

5. At room temperatures, the sulfate anion,  $\text{SO}_4^{--}$ , seems to have the greatest effect in slowing the rate of reaction and formation of calcium carbonate; the chloride anion,  $\text{Cl}^-$ , has less effect. The most rapid reaction, of course, is the simple one of lime with  $\text{Ca}(\text{HCO}_3)_2$  in solution. The presence of sludge or solid  $\text{CaCO}_3$  at room temperatures permits reactions to take place at high speed, regardless of the anion type, with a given excess of chemical softening reagent.

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## Taste and Odor Control in Indiana

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**J. G. Filicky**

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*A paper presented on Feb. 10, 1955, at the Indiana Section Meeting, Indianapolis, Ind., by J. G. Filicky, Research Chemist, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa.*

AS far back, perhaps, as prehistoric times, man has recognized clear, sparkling spring water as the ultimate in quality. This is so, first, because spring water is clear and sparkling. Today these characteristics are known as freedom from turbidity and color, the standards of which, in the majority of water purification plants, consistently equal or surpass most spring waters.

Second, spring water is assumed safe to drink. Unfortunately, it has been learned from sad experience that spring and well supplies can often be contaminated, thus being directly responsible for epidemics. Certainly, the water supply field can be justly proud of its excellent record of supplying safe water to consumers at all times. Achievement of the high standards of quality has been a long uphill battle. Yet, with modern equipment, skill, and close supervision, miracles have truly been accomplished, considering the highly turbid, colored, and polluted sources often used.

Spring water is further expected to please the palate, that is, to be free from any detectable taste or odor. Some water supplies fail to meet this standard. Offending odors include aromatic, chlorinous, earthy, fishy, medicinal, musty, pigpen and an assortment of others. Any detectable

odors in water are objectionable to the average consumer, so if they become sufficiently intense, he will seek a more pleasing supply. The more discriminating individual will select a bottled water, but others may choose unsafe sources, which could lead to epidemics. Thus, delivery of palatable water at all times constitutes a safeguard to citizens of the community.

The author has participated in taste and odor studies at six Indiana water treatment plants. At everyone the officials have recognized the importance of achieving all the attributes of spring water. The raw supply of each of the plants studied presents a serious odor problem, yet the consumer is supplied with agreeable water practically all of the time.

One of the first requirements for producing palatable water is to set up a definite standard. This is accomplished by using the threshold odor test, which all six plants employ daily and sometimes even hourly if conditions demand. Usually a threshold odor number of five is within the desired limits, so that this is set as a standard. Occasionally, a specific type of odor will require even closer limits. Under such circumstances, taste tests should be conducted in order to determine a new standard.

## **Treatment Methods**

Although many preventive methods are available, this discussion is concerned principally with corrective measures. The principal ones are described briefly, as the six plants mentioned use a wide variety.

Activated carbon removes odorous compounds by adsorption, so that these materials are actually taken out of the water when the carbon is removed in the sedimentation basin or sand filters. With the proper usage of a suitable activated carbon, any taste and odor conditions can be satisfactorily controlled.

In addition to adsorption, the oxidation principle has been employed for control of tastes and odors. Under this classification there are: (1) aeration; (2) free residual chlorination; (3) chlorine dioxide; and (4) ozone. The degree of oxidation potential will vary with each of these treatments, but—with the possible exception of aeration—they depend upon changing the chemical structure of undesirable compounds to nonodorous materials. Through years of actual usage on many types of taste and odor conditions, the various oxidation methods have been found specific for certain types of pollution, but are not, by any means, a taste and odor cure-all. Thus, these treatments usually must be supplemented by an application of activated carbon.

Many plant operators have developed adequate ways of removing tastes and odors with some combination of the oxidation methods with activated carbon. The remainder of this paper deals with several plants which use activated carbon, with or without other types of treatment to produce a palatable water.

## **Plant 1**

The water source is heavily polluted by industrial wastes and sewage. Variations in type and intensity are reflected in rapid and extreme changes in the threshold odor value of the raw water. The tastes are usually intensified during the winter months, probably because volatilization and biological action are at a minimum; it is not unusual to have threshold odor values as high as 5,000.

The raw water passes through two ozone diffusion towers in parallel into an around-the-end baffle type of mixing basin where ammonia, chlorine, and alum are added. When the concentration of oils in the water is excessive, clay and iron sulfate are also added. When the threshold odor value of the deozonated water exceeds a certain value, activated carbon is added near the end of the mixing basin, which has a detention time of approximately 5 min. After sedimentation and filtration, the water is post-chlorinated.

It has been found that ozonation alone will provide as much as 85 per cent reduction in the hydrocarbon type of odors present. In spite of this, it has been found necessary to use additional treatments to provide a completely palatable water. Ammonia is added to the ozonated water prior to the application of chlorine, to prevent the latter from reacting with certain compounds and intensifying the tastes and odors. When excessive surface oils are noted on the water, clay and ferric sulfate are added to improve the alum coagulation by adsorbing as much of the oils as possible. Finally, reliance is placed in activated carbon to adsorb the residual taste and odor bodies, so as to provide a completely

palatable water with a threshold odor value of approximately 4 or less. During severe taste and odor conditions, activated carbon in dosages as high as 400 ppm has been applied as a split treatment. That is, part is added to the raw water at the mixing basin, and the remainder is applied to the settled water. The amount added to the latter is dependent on the odor reduction achieved by the raw-water application. Threshold odor tests are conducted at intervals to keep the staff informed of the latest conditions.

### Plant 2

The water source is subject to industrial and sewage pollution, but not to the same degree as in Case 1. Although the wastes are diluted before reaching the intake, precautionary measures are employed to determine any changes that may occur in the raw water, while the odor intensity is determined every 1-2 hr by the threshold test. The activated carbon dosage is obtained from an adsorption curve based on the amount of carbon required to reduce a given raw-water threshold odor number to a lower level.

In order to insure the production of a palatable water at all times, a procedure has been set up to evaluate the taste and odor quality of the water at the end of the mixing basin. This is done approximately 30 min after the activated carbon application. A sample is filtered through an odor-free sand bed in the laboratory to remove the floc and carbon, dechlorinated, and examined to determine the threshold odor. If it is within the proper level (usually about 4 or less), no adjustment in carbon feed is necessary. As a further check on the palatability, the water sample is also tasted, as the taste does not necessarily parallel the odor

value. If the tests show that the treatment has not been adequate, a secondary dosage of carbon is applied to the settled water to prevent taste and odors from reaching the distribution system. Recently, a threshold odor value of 500, with a refinery sewage odor was encountered. An application of 120 ppm activated carbon produced a palatable water.

Normally, ammonia is added to the raw water, followed somewhat later by chlorine, and still later by activated carbon, part way through the mixing basin. At the head of the mixing basin, alum is added for coagulation. With this procedure, the chlorine reacts with the ammonia, forming chloramines rather than compounds whose taste and odor may be intensified. A chloramine residual in the finished water minimizes chlorinous tastes and odors. Moreover, this chemical is more stable than chlorine, and less adsorbable by carbon, the efficiency of which is thus increased.

The complete treatment plant consists of a primary settling well, mixing basin, settling basin, and filters. The proper use of activated carbon has produced a palatable water under all conditions, so that there have been no consumer complaints about taste and odor in 2 years.

### Plant 3

Raw water comes from a river which is subject to sewage and phenolic-waste pollution. Some tastes and odors also arise from natural causes such as algae growths. Usually, very little difficulty is experienced except for the severe problem arising from medicinal tastes and odors caused by chlorination of the phenolic wastes.

The method formerly used to remove the phenols was adsorption with acti-

vated carbon. There were times, however, when sufficient phenol remained after the treatment to produce a medicinal taste upon chlorination. To eliminate or minimize this, chlorine was used in combination with ammonia. This method of disinfection measurably reduced the formation of chlorophenolic tastes. At times, however, carbon dosages of 30 ppm did not remove all the phenol and subsequent chlorine-ammonia treatment produced some medicinal tastes. Sometimes these were more pronounced in the distribution system than at the plant, probably owing to a delayed reaction. This difficulty has been overcome by the application to the filter effluent of chlorine dioxide, oxidizing phenolic compounds to tasteless end products. On a cost basis, the oxidation process for eliminating the phenolic tastes and odors was approximately equivalent to adsorption by activated carbon. The former, however, had little, if any, effect on tastes and odors from sewage pollution or natural causes.

The taste problem was somewhat aggravated by the softening of the water with lime, raising the pH to 10.5 or higher. Phenol above pH 8.5 will react with the alkali present to form phenolates, which are quite difficult to adsorb with carbon. Thus at elevated pH values, efficiency was somewhat reduced. Because the carbon was added to the mixing tanks along with the lime, adsorption taking place under adverse conditions, the point of carbon application was moved from the mixing basin to a place before the addition of softening or disinfecting chemicals.

The plant has primary mixing tanks equipped with motor-driven, vertical-shaft paddle mechanisms for mixing chemicals with the raw water, which then flows through coagulation tanks,

clarification tanks, and into the primary-carbonation tanks. The treatment in these is followed by a secondary mix, clarification, settling, secondary carbonation, and filtration.

#### Plant 4

The source is a river subject to industrial and domestic pollution, as well as odors from natural causes. The raw water is pumped into a 300-ft flume where the chemicals are added. These consist of alum for coagulation, chlorination to a free residual, lime for pH adjustment, copper sulfate for algae control, and activated carbon, when used. The water from the flume divides, each portion flowing through a slow-mix basin and clarifier. The water from the clarifiers then converges, flows through the settling basins, and passes to rapid sand filters. The plant is quite flexible, from a standpoint of chemical applications and mode of processing.

Constant taste and odor problems have caused various methods of treatment to be used. At one time, almost complete reliance was placed on free residual chlorination and chlorine dioxide. The overall results obtained by these were not satisfactory. Partial reductions in tastes and odors were noted with the use of free residual chlorination, but the improvements in most cases were not sufficient. Chlorine dioxide applied to the clear well was found effective for eliminating the medicinal tastes associated with phenolic compounds, but was not found effective for tastes and odors associated with vegetation, algae, and various types of industrial pollution. Activated carbon is now applied continuously, the dosage adjusted to changing conditions as indicated by odor and taste tests. The carbon and chlorine are added to the raw water almost si-

multaneously, so it is possible that a more efficient use of each chemical could be realized by applying the former about 15 min ahead of the latter. As it is, the supplemental use of activated carbon has been able to control tastes and odors effectively.

### Plant 5

The raw water supply is subject to heavy industrial pollution, chiefly from oil refineries. In order to stay abreast of the changes in the tastes and odors of the supply, the threshold odor test is conducted at regular intervals. The activated carbon application may then be adjusted to produce a palatable water.

The processing plant consists of mixing, settling, and filtration units. Ammonia is added to the suction well just ahead of the mixing basin, where alum, chlorine, and carbon are applied. The latter is added to the water several minutes after the chlorine, thus allowing adequate mixing and sufficient time to form chloramines. The ratio of chlorine to ammonia is generally 3:1, and the finished water has a combined chlorine residual, resulting in a minimum of chlorinous tastes and odors.

Studies have involved the use of chlorine dioxide and free residual chlorination, the results of which have not been entirely successful. Although the former has been effective in combating the medicinal tastes and odors associ-

ated with phenolic compounds, little, if any, effect was noted on the oil refinery types. These latter were actually intensified by free-residual chlorination.

### Plant 6

Odors in the raw water were predominantly of natural origin. The facilities consist of a raw-water well, mixing basin (where carbon is added), settling basin, and filters. The chemicals, added at the well, include alum for coagulation and sufficient chlorine to carry a free residual through the filters. Ammonia is applied to the clear well effluent to provide a more stable combined chlorine residual in the distribution system as well as to minimize the chlorinous tastes and odors. Free residual chlorination only partially reduced the tastes and odors encountered; therefore, activated carbon was used as a supplemental treatment to produce a palatable water.

Officials of the plants visited by the author have achieved excellent results. Every effort, at all times, is being directed toward production of palatable water. The plants are utilizing almost every method of odor control in suitable combination to fit specific needs. In new installations that are being designed for use where odor control is a problem, provisions for flexibility of operation would be extremely beneficial in ultimate chemical treatment.

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## Discussion

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### A. E. Griffin

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In taste and odor control, particularly where corrective measures are necessary, it is very important that the

operator use his skill and knowledge in integrating or blending the various means available for producing a palatable water. If the only function of water treatment were taste and odor control, processing would be very simple. Unfortunately, water usually con-

tains bacteria, some coloring matter, and a varying amount of suspended material. In addition, the supply can be acid and corrosive or hard and likely to cause incrustation. All of these characteristics demand special treatment, in the course of which, original tastes and odors may be intensified or new ones developed. The operator must be prepared to cope with each situation as it arises.

The paper divides corrective treatment into two classes, adsorbents and oxidants. Data are presented showing how they have been integrated to produce an acceptable product from questionable sources. This mixture of methods is the correct approach, because very frequently the success of each treatment depends upon the proper functioning of one or more other processes.

### Adsorption

Filicky is not exaggerating when he says that with the correct use of a suitable activated carbon, any taste and odor condition can be satisfactorily controlled. This is true, but the employment of carbon alone can make the cost prohibitive, particularly when it becomes necessary to use granular-carbon filter beds and, perhaps, powdered carbon. In certain instances, even such expense is justified, exemplified by several cities which take their supply from Lake Winebago, Wis. The algal odors at times are so intense that all of the water must be passed through beds of granular activated carbon. Generally, proper handling of other methods can usually reduce the dependence on carbon treatment.

Aeration, free residual chlorination, chlorine dioxide addition, and ozonation are given as the outstanding examples of use of the oxidation prin-

ciple, by which the taste and odor components of water are either oxidized to inoffensive forms or changed so that subsequent treatment will not produce objectional products. The role which these methods play and the manner in which each can supplement the other always warrant discussion.

### Aeration

Aeration is not a particularly good or efficient way of oxidizing tastes and odors, because the method depends on the amount of air that can be absorbed. When used properly and where warranted, the air does an excellent job, but cannot be compared to chlorine, chlorine dioxide, or ozone as an oxidant.

Aeration acts in two ways: it makes possible the release of volatile compounds from the water and allows the dissolving of air in the water. The outstanding example of aeration providing an oxidant is in the treatment of water containing hydrogen sulfide. Aeration releases part of the hydrogen sulfide directly to the atmosphere. The remainder is then slowly oxidized, within 1-2 hr. The volatilization of dissolved odors is far more valuable than the oxidation. Aeration releases many natural and industrial odors much more cheaply than any chemical method can do or diminishes such ingredients to a degree where they can be economically handled by subsequent methods. For instance, at Institute, W.Va., a few years ago, tastes and odor of butadiene origin were reduced to the point where they could be efficiently treated.

Aeration of raw waters for odor control—other than for the removal of dissolved gases such as hydrogen sulfide or trade wastes—is somewhat out of fashion. On the other hand, aeration

within or subsequent to the treatment process is now of considerable importance because it is recognized that volatile odors produced during treatment should be removed before the water is sent to the distribution system.

### Chlorination

Chlorination can be used to kill bacteria without affecting odors one way or the other or can be used to oxidize odors to nonodorous forms. This halogen, particularly when not used properly, sometimes produces or emphasizes odors.

Chlorine is used primarily for disinfection, but inasmuch as color reduction, oxidation of iron and manganese, filter improvement, and taste and odor elimination may be obtained at the same time, as extra benefits, chlorination must always be in careful control. To obtain the full benefits, it is imperative that the operator be fully informed about conditions under which chlorine will function in relation to pH, ammonia, organic matter, dissolved gases, certain metals, temperature, sunlight, and aeration. He also should be conversant with the general characteristics of the various types of chlorine residuals.

Proper control reduces the tastes and odors as far as possible without the production of chlorinous odors. For instance, chlorine, if applied in sufficient quantities to produce a free residual, where a 2-3-hr contact is available, will oxidize phenolic compounds without forming chlorophenolic tastes and odors. These can also be held to a minimum by adding ammonia and chlorine, in a ratio of approximately 3:1. Unfortunately, the bacterial reductions may not be sufficiently great enough to meet the standards of local health authorities. If, however,

chlorine is added without regard to the breakpoint reactions in quantities just sufficient to produce a residual which falls at the top of the breakpoint curve, not only will chlorophenolic tastes result (when the raw water contains phenols), but the natural tastes and odors of the raw water may be emphasized. These odors are difficult to remove either by aeration or activated carbon. By using the breakpoint process, however, quick and adequate disinfection can be accomplished without imposing what at times might amount to an impossible load on other corrective measures.

Although phenolic and other tastes and odors can be removed or prevented by using free residual chlorination, there is always the possibility that a small amount of nitrogen trichloride—an end product in the oxidation of ammonia by chlorine—may be produced. The quantity can be reduced by holding the pH of the water at approximately 8.0, aeration, dechlorination, using activated carbon, or converting the free available chlorine residual in the finished water to chloramines by postammoniation.

Nitrogen trichloride, very small amounts of which produce a persistent and irritating odor, is found only when ammonia—either as free albuminoid or as ammonia—is present. When there is none, any residual produced will be tasteless and odorless (up to 4.0-6.0 ppm) free available chlorine. The only chlorinous taste or odor that can be readily distinguished is composed of chlorine compounds such as addition or substitution products.

Sometimes the characteristics of the raw water change so rapidly that the only recourse—if a bacteria-free water is desired—is to chlorinate well beyond the breakpoint and maintain a free

available residual of several parts per million throughout the treatment process and to the filter beds. This practice, at times amounting to superchlorination, may result in a fluctuating residual, often leading to tastes and odors in the finished water. The difficulties can be overcome by dechlorination, either to zero or to a workable residual of approximately 0.5–0.75 ppm, on top of the filters, together with the use of carbon.

There are many instances where the mere raising of the chlorine dosage by only a few parts per million, just enough to get over into the free available chlorine zone, has completely rid the water of all tastes and odors. This has been particularly true where *Synura* are present, although *Anabaena* have also responded. Such treatment has been particularly effective where filters are not available.

#### Chlorine Dioxide and Ozone

Chlorine dioxide is an excellent agent for chlorophenolic-odor destruction, the speed of which is truly startling. If the chemical is applied to the suction side of a pump, the chlorophenolic odors will have disappeared by the time a water sample can be drawn from the discharge side. The amounts of chlorine dioxide required are relatively low, usually amounting to no more than 6 lb sodium chlorite per million gallons (0.71 ppm). The efficacy of chlorine dioxide on other than chlorophenolic odors is less dramatic, prob-

ably being about as great as free available chlorine.

Application of ozone, used almost exclusively in the United States for taste and odor control, has been very limited, probably in large part because of the cost.

#### Conclusion

The operator must properly integrate the special characteristics of the various processes into an efficient treatment. To do this successfully, he must have adequate equipment and the proper chemicals. Insufficient treatment, applied too late, is often worse than none at all.

The plant as a whole must be taken into consideration, even the coagulation process, because this and sedimentation can be quite important in solving the problem. If the sludge is not withdrawn at the proper time, it may generate odor that must be removed later; if the filters are dirty, they may impart odor to the filtered water. These odors may come from the accumulations of dirt in the sand or from the activity of various bacteria. The former difficulty can be overcome by cleaning followed by coagulation to the point where little dirt goes to the filters. The bacteria problem can be solved by carrying a free available chlorine residual to and through the filter medium.

The proper use and integration of the various corrective methods will produce the palatable grade of water outlined by Filicky.

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## Relation of Coliform-Organism Test to Enteric-Virus Pollution

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**F. Wellington Gilcreas and Sally M. Kelly**

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*A paper presented on Apr. 21, 1955, at the New York Section Meeting, Buffalo, N.Y., by F. Wellington Gilcreas, Asst. Director, and Sally M. Kelly, Sr. Research Scientist, both from Labs. & Research Div., State Dept. of Health, Albany, N.Y.*

**F**OR more than 50 years the accepted criterion of water quality has been the coliform index. It has been an invaluable aid to the sanitarian in evaluating the efficiency of treatment processes for public water supplies and has been the basis of bacteriologic water quality standards. The index, however, applies only to intestinal pathogens of bacterial nature and may not indicate the presence of other types of pathogenic agents. Among these are the viruses, some of which are enteric in habitat. Because they have been isolated from fecal matter and sewage, they may present a definite pollution hazard in water supplies. Consequently, water works men may wonder if a satisfactory coliform index derived in accordance with the technique given in *Standard Methods* (1) actually indicates freedom of the supply from viruses. In satisfying this question, the problem has been to determine: [1] whether viruses can be detected in water; [2] how their survival under different supply treatment procedures compares with the survival of coliform bacteria; and [3] whether the presence or absence of members of the coliform group can be used without reservation to indicate the biologic quality of water.

Previous publications concerned with the problem under discussion have presented methods applicable to virus detection in water and sewage (2) and data indicating that, under certain conditions of water treatment, the coliform index may be taken to indicate freedom from virus pollution (3). These studies have been extended to provide further information concerning the effectiveness of other supply treatments to insure that water free from bacterial pollution as measured by the coliform index can be assumed also free from virus pollution.

### Virus Pollution

Such viruses as those causing poliomyelitis and hepatitis and the Coxsackie groups have been isolated repeatedly from sewage and have, on the occasion of disease outbreaks, been incriminated as water supply contaminants. To isolate these viruses quantitatively requires difficult and time-consuming techniques. Therefore, comparative survivals of typical enteric viruses and coliform organisms were investigated to determine if the coliform test is also a reliable measure of virus contamination.

The agents used were: *Esch. coli*, Strain 3,635, as phosphate-buffered di-

lutions of an 18-hr broth culture, giving an initial MPN per milliliter of approximately  $10^4$ ; Group A, Type 5 strain of the Coxsackie viruses, as spring water dilutions of suckling mouse leg suspensions, giving initial median effective doses (MED) of approximately 8.0; Theiler (T.O.) virus, Strain 4,727D, or GD VII virus, as spring water dilutions of adult mouse brain suspensions, giving initial MED

100 ml by inoculation of three or five lactose fermentation tubes. Bacteriophage particles were counted as plaques formed on crystal violet agar plates in triplicate seeded with *Esch. coli* B (4).

Theiler virus measurements were determined as the MED † required for limb paralysis in mice weighing 10-12

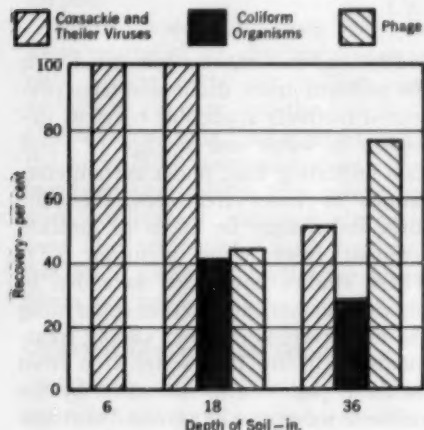


Fig. 1. Soil Penetration

Suspensions of Coxsackie virus and *Esch. coli* in water were percolated through garden soil in three glass tubes 6 in., 18 in., and 36 in. long. The resulting percolates show that at least 3 ft of travel is necessary to reduce the virus and coliform content of water.

values of approximately 5.5; or *Esch. coli* B bacteriophage, Strain T4r,\* as spring water dilutions of a broth stock, giving an initial particle count per milliliter of approximately  $10^4$ .

*Esch. coli* numbers were determined as tryptone agar plate counts in triplicate or as MPN of microorganisms per

\* Obtained from Seymour S. Cohen, University of Pennsylvania, Philadelphia.

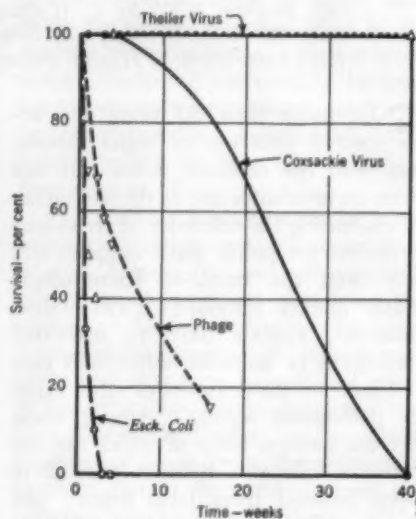


Fig. 2. Storage of Viruses and Coliform Bacteria in Water, 8°-10°C

The viruses show greater powers of survival at this temperature range than does *Esch. coli*.

g during a period of 21-30 days following injection intracerebrally with suspensions containing Theiler virus. Coxsackie virus was determined as the MED required to produce limb paralysis in 3-day-old mice during the 10-14 days immediately following intraperitoneal injection with suspensions containing Coxsackie virus.

† MED determined by moving-averages method of Thompson (5).

### Soil Percolation and Storage

Seepage of water through soil has a dual role as far as pollution problems are concerned. In the drainage of surface waters, seepage through soil may provide purification. Seepage may also, however, serve as a channel from a highly polluted source (such as a privy or cesspool) to an unpolluted one. For example, a virus causing hepatitis (6) has been found in well water near cesspools receiving contaminated wastes, while the instances of similar pollution by enteric bacteria are numerous. The comparative behavior of enteric viruses and bacteria

and even that distance of travel, however, was insufficient to remove them completely.

The relative survival of viruses in comparison to coliform bacteria during storage in water is important because storage is a common water works practice. Water and sewage suspensions of Coxsackie and Theiler viruses, *Esch. coli* B bacteriophage, and *Esch. coli* were dispensed in 10-ml portions and stored in several screw-capped test tubes at room temperature (20°–30°C) and lower (8°–10°C) for a period of 40 weeks. Amounts of virus and coliform bacteria present in the suspensions were determined initially

TABLE 1

Initial Counts of Microorganisms in Storage

Type	Organisms No./ml		MED
	Water	Sewage	
<i>Esch. coli</i>	5,400	6,000	
<i>Esch. coli</i> B bacteriophage	10,870	18,500	
Theiler virus			6.0
Coxsackie virus			7.8

during seepage of water through soil is of importance in determining the validity of the use of the coliform index under such conditions. To compare the penetration of viruses and bacteria through soil, suspensions of Coxsackie virus and *Esch. coli* in water were allowed to percolate through garden soil (moisture content, 4 per cent) contained in glass tubes 36 mm in diameter; a mixture of the agents in 300 ml of spring water was added to 6-, 18-, and 36-in. columns of soil and the percolates were collected (see Fig. 1). Percolation through at least 3 ft of soil was necessary for the reduction of either viruses or coliform organisms,

TABLE 2

Survival of GD VII Virus in Unpurified and Purified Form

Storage Time days	Median Effective Dose			
	8°–10°C		20°–30°C	
	Unpurified	Purified	Unpurified	Purified
0	6.2	6.5	6.2	6.5
3	6.2	6.2	6.2	6.5
14	6.2	6.5	<5.0	6.2
21	6.0	6.5	<3.0	6.3

(see Table 1) and at various intervals by titrating aliquots of the suspensions in individual tubes which were then discarded. In both water and sewage, viruses survived for a longer period of time and to a greater extent than did *Esch. coli* (see Fig. 2) when stored in the cold. By the third week of cold storage, the coliform bacteria had dropped to 1 per cent of their original number, while virus survival continued unchanged for at least 4 months. Even after 10 months in the cold, there was little destruction of virus. It made no difference in rate of destruction of the

agents stored in the cold whether they were in water or in sewage.

Differences were found in the relative survival of the two types of agents in cold water and in water at room temperature. In both water and sewage, *Esch. coli* reproduced under storage conditions at room temperature (see Fig. 3). Survival of viruses at room temperature was much briefer than in the cold: Coxsackie virus was

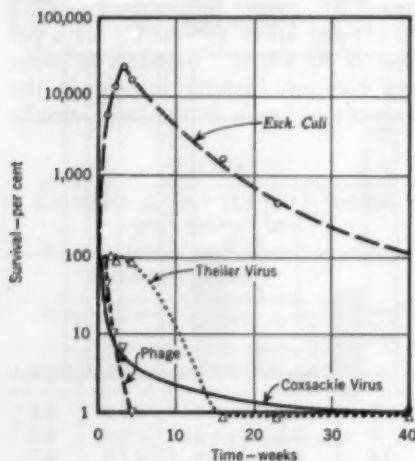


Fig. 3. Storage of Viruses and Coliform Bacteria in Water, 20°-30°C

At this temperature range, *Esch. coli* reproduce and survive in greater proportions than the viruses.

partially destroyed by the third week and Theiler virus by the sixteenth week. Examination of the titers of these two during storage indicates that, in general, Theiler virus is more stable during storage than the Coxsackie virus strain used. When the agents were stored in sewage rather than in water, coliform organisms reproduced at a greater rate and bacteriophage was destroyed at a slower rate.

The variance in survival rate of viruses and coliform bacteria in the cold raised the question of what factors contribute to this effect. One possibility is a protective action of tissue suspension components which accompany virus preparations. Proteins in the suspensions have a reputation for exerting a protective effect on viruses. On the other hand, purified virus suspensions might be suspected of being less stable in water storage. To test this, survival of GD VII virus in mouse brain suspension diluted with phosphate-buffered water (5) was compared with survival of virus that was of similar origin but which had been purified by ion-exchange resin adsorption (2). The effect of cold storage on viruses was approximately the same, irrespective of purification state. At room temperature, however, the purified virus survived to a greater extent than the unpurified (see Table 2), suggesting that the protein of virus-containing tissue suspensions may not be the component that exerts a protective effect, as the purified preparations had approximately 96 per cent of protein *N* removed.

The prolonged survival of purified virus at room temperature was investigated further. In the final purification step, virus is eluted from resin with 10 per cent phosphate ( $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ ). The addition of phosphate, then, was suspected of contributing to the prolongation of virus survival at room temperature. To test this hypothesis, the effect of storage at room temperature was compared among unpurified virus, unpurified virus to which phosphate was added, and purified virus. The survival rate of the latter two suspensions was approximately equal to each other and greater than that of unpurified virus (see Table 3). It was desired to know what con-

concentrations of phosphate exert this effect. Unpurified virus suspensions were stored for several weeks at room temperature in dilution water to which was added these amounts of disodium phosphate: 0, 0.14, 0.28, and 0.56 millimoles. Survival of virus in water with the added phosphate was greater than that of virus in water with no added phosphate (see Table 4). That pH change did not contribute to the difference in survival rate is clear.

to remove colloidal matter and bacteria—did not completely free water from the viruses of poliomyelitis (7, 8) and hepatitis (9). Flocculation, carried out as described in the following paragraph, removed bacteriophage and Theiler and Coxsackie viruses from water to a small degree (as well as coliform bacteria), though by no means exhaustively (see Fig. 4). In the experiments, 200–250 ml of sterile spring water in 1-liter beakers was inoculated

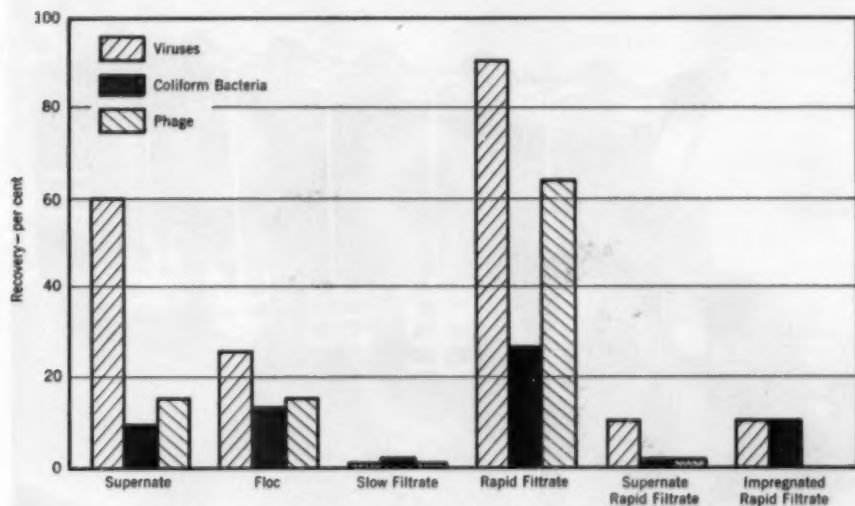


Fig. 4. Flocculation and Filtration of Viruses and Coliform Bacteria in Water

Rapid sand filtration even in combination with flocculation removes the agents only partially.

Salts other than phosphate may exert a similar protective effect on animal viruses in storage. The experiments presented here offer the practical implication that virus survival may be increased in natural waters that are high in phosphates.

### Flocculation

In early experiments, flocculation with aluminum sulfate—long employed

with *Esch. coli* and one or more of these agents: Coxsackie virus, Theiler virus, and *Esch. coli* B bacteriophage.

After mixing and removing aliquots to determine titers of the original suspensions, 0.8–1.0 ml of a 17.4 g per liter solution of aluminum sulfate ( $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ ) was added to the water. The water was stirred rapidly for a few seconds and then slowly for 15 min by a motor-driven, bladed appa-

ratus (Fig. 5). The floc was allowed to form for 1 hr at room temperature ( $22^{\circ}$ – $23^{\circ}\text{C}$ ). The amount of aluminum sulfate chosen had been determined previously as the optimum concentration for floc formation. Aliquots of supernatant fluid were drawn off and microorganism titers determined, and the remaining supernate was

over 99.99 per cent removal of bacteriophage. That the agents in the formed floc are not destroyed is clear from their recoveries in the floc fraction. Although aluminum sulfate is not a commonly used virus precipitant, this observation suggests the chemical has possibilities and implies that if flocculation were used to remove infective sub-

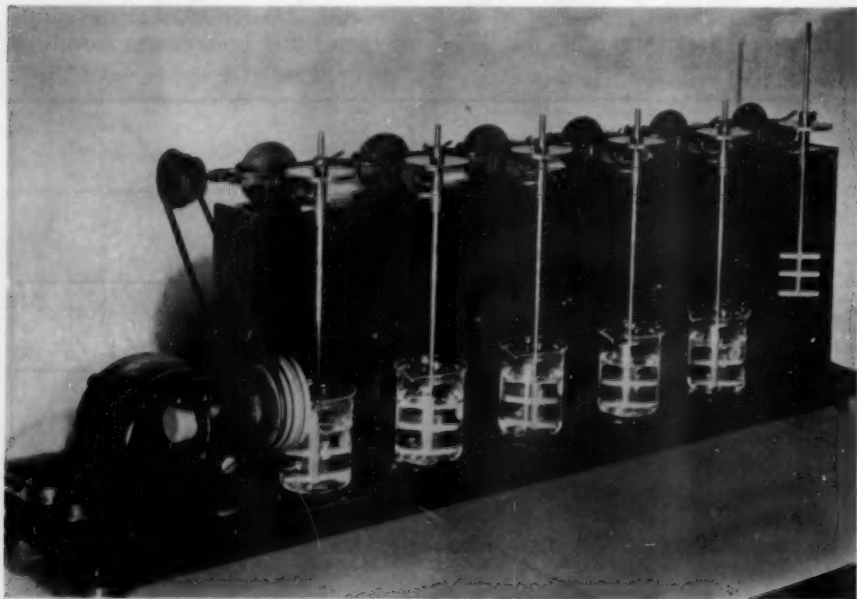


Fig. 5. Multiple-Blade Stirrer

*This motor-driven apparatus was used for the flocculation experiments (see Fig. 4, p. 687).*

saved for sand filtration. The settling flocs were centrifuged at 3,400 rpm for 10 min and suspended in 1–3 ml of spring water, and microorganism titers were determined. Flocculation removed both viruses and coliform bacteria only partially from water (see Fig. 4). The extent of removal by flocculation is considerably less than reported by Chang (10), who obtained

stances from water, the floc formed might constitute a concentrate of such material.

#### Filtration

Sand filtration was carried out at both a slow and a rapid rate on a laboratory scale by allowing the flocculation supernates or water suspensions containing a mixture of the agents to

filter through a model of a rapid sand filter (see Fig. 6). The filter consisted of a 30-in. column of white sand with an effective particle size of 0.425 mm and a uniformity coefficient of 1.62. The sand was supported by 11 in. of gravel contained in a glass tube 40 mm in diameter, representing a longitudinal section through a rapid sand filter.

*Slow filtration.* Flow through the filter at the slow rate was 10 ml per minute or 0.2 gpm per square foot. Retention time on the filter was 2-4 min. The filter, used either dry or wet with spring water, retained approximately 25 ml of the original suspension. When the filter was wet before

head of liquid above the filter remained constant. Rapid filtrations were carried out on 1.5-liter amounts of: suspensions containing a mixture of the agents; supernatant fluids after removal of floc; and suspensions after the filter had been impregnated with alum and floc by previous filtration of flocculation supernates. Before collection of filtrates, at least 450 ml of each liquid was allowed to pass through the filter to eliminate obvious dilution effects from previous filtrations, as that volume was approximately equal to the amount of liquid contained in the filter. Between filtrations of the suspension

TABLE 3  
*Survival of GD VII Virus at 20°-30°C*

Storage Time weeks	Median Effective Dose		
	Purified	Unpurified (Plus Phosphate)	Unpurified
0	5.6	6.5	6.5
1	5.6	6.0	6.0
2	5.3	6.5	5.8
4	5.3	6.5	<4.0
6	5.1	6.0	<4.0

filtration proceeded, aliquots for determining the titer of agents in the filtrate were not collected until a volume equal to that used to wet the filter had passed. Slow filtration removed all the agents to a great extent (see Fig. 4), although this process alone was somewhat less effective than in combination with flocculation.

*Rapid filtration.* Flow through the filter at the rapid rate was 100 ml per minute or 2 gpm per square foot. The suspensions were fed to the filter from a reservoir at such a rate that, in combination with an overflow tube, the

TABLE 4  
*Effect of Phosphate on Survival of GD VII Virus at 20°-30°C*

Storage Time weeks	Median Effective Dose			
	Phosphate—millimoles			
	0*	0.14†	0.28‡	0.56§
0	3.8	3.8	3.8	3.8
2	<1.0	3.8	3.0	3.8
4	1.5	3.8	3.8	3.0
6	<1.0	3.5	3.8	3.8

\* pH 6.9-7.0.

† pH 7.6-7.7.

‡ pH 7.5-7.4.

§ pH 7.8-7.7.

and the supernatant fluid, the filter was rinsed with tap water. Rapid filtration (see Fig. 4) of the suspension did not remove the agents, bacterial or viral, to a satisfactory extent. Somewhat greater amounts of bacteria were removed than viruses, but far from completely. Filtration of supernatant fluid after flocculation removed large amounts of the agents from the suspensions, although, of course, some had been removed previously by the flocculation step. Filtration of suspension on the impregnated filter also removed

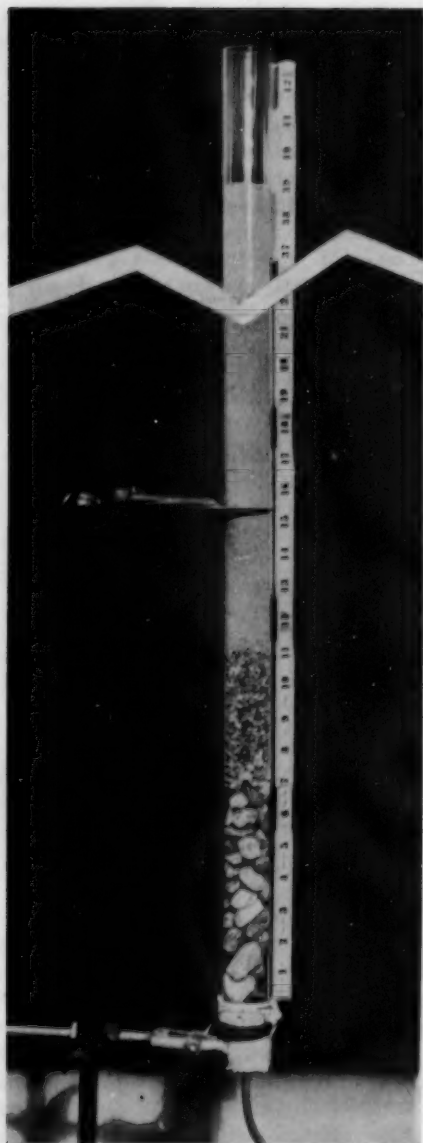


Fig. 6. Rapid Sand Filter Model

Filtration experiments were performed on a laboratory scale with this apparatus. The glass tube is 40 mm in diameter.

large amounts of the agents. These results are in accord with those of other workers who found that rapid sand filtration alone is not an effective means of removing viruses.

### Disinfection

Chlorination had previously been found (3) to destroy viruses less effectively than bacteria. To verify this observation, chlorination experiments were repeated, using Cocksackie rather than Theiler virus as the suspension in spring water. The process killed *Esch. coli* at doses as low as 0.1 ppm chlorine (see Table 5), but it required a concentration greater than 0.2 ppm to destroy virus (see Fig. 7). These experiments indicate that the coliform index may not be an adequate measure of pollution by viruses when chlorination alone is the water treatment in practice. Among recent investigators, Clark and Kabler (11) found that free chlorine residuals of 0.27-0.32 ppm were required to destroy purified Cocksackie virus under similar experimental conditions.

### Sewage Pollution

As the coliform index is used to determine not only the safety of potable waters but also the degree of pollution by sewage in receiving streams, it is valuable to know if the index can be used as an indicator of viral pollution of sewage. Swab sampling at two sewage treatment plants yielded 48-hr specimens of raw and treated sewage which were examined for naturally occurring coliform bacteria, *Esch. coli* B bacteriophage, and Cocksackie viruses. Coliform determinations by the violet-red agar plate count gave results comparable to those by the fractional dilution and lactose fermentation procedure. In reporting results, therefore,

the numbers of organisms obtained from these two measurements were averaged. Because freezing was found to produce no significant change in coliform or Coxsackie virus content of sewage, the samples were frozen in a dry-ice chest for convenience before examination.

Fluctuations in coliform content of the sewages sampled were great—MPN per milliliter varied from 20,000

in the summer months (12). *Escherichia coli* B bacteriophage content of the sewage samples fluctuated by a factor of 100 during the months of sewage examination and, like coliform content, exhibited no consistent pattern of fluctuation. Variation in Coxsackie virus content differs from that of the other agents determined; it appears in sewage from June through November, in greatest amount from July through

TABLE 5  
*Survival of Esch. coli and Coxsackie Virus*

Chlorine Dose ppm	Chlorine—ppm				Esch. coli No./ml	Coxsackie Virus MED
	Residual			Demand		
	Free	Combined	Total			
0.0					2,600	7.1
0.5	0.00	0.00	0.00	0.05	2,200	7.8
	0.00	0.00	0.00	0.05		
	0.00	0.00	0.00	0.05		
0.1	0.00	0.01	0.01	0.09	30	7.7
	0.00	0.02	0.02	0.08		
	0.00	0.00	0.00	0.10		
0.2	0.00	0.00	0.00	0.20	0	7.3
	0.00	0.06	0.06	0.14		
	0.00	0.02	0.02	0.18		
0.5	0.04	0.04	0.08	0.42	0	<4.8
	0.03	0.12	0.15	0.35		
	0.02	0.085	0.105	0.395		

to 20,000,000—and followed no discernible pattern (Fig. 8). Occasional samples taken at other times of the year—November, February, and March, for example—gave coliform counts comparable to those in samples obtained from June to October. This patternless fluctuation at Albany and Colonie, N.Y., is apparently not universal, because many sewages have a greater number of coliform organisms

September, and sporadically, if at all, from December through May. It is clear that the coliform index is not an adequate measure of pollution by viruses in sewage, as fluctuations in virus content were not marked by comparable changes in coliform content.

To determine the effect dilution has on the utility of the coliform index as a measure of pollution by viruses, three types of observations were made;

1. Sewage effluents were compared for their naturally occurring coliform and Coxsackie virus content, in anticipation of comparable decreases in coliform and virus content following sewage treatment, which, however, did not bring about a reduction; thus, dilution effects were not apparent.

2. The incidence of virus was compared with that of coliform organisms

these sites, taken to indicate degree of dilution. Viruses were found at the outfall and at one of the river points (see Table 6). This observation suggests that, in receiving streams where dilution of sewage effluents is by a factor of 35 or less, Coxsackie viruses may be detected.

3. The incidence of virus in swab samples of raw and treated sewage throughout the year was compared with coliform numbers in the same specimens. In none of these were viruses found when the coliform MPN per milliliter of the sample was less than 13,000.

TABLE 6

*Coxsackie Virus Isolations From Sewage Treatment Plant Outfall*

Site	Coliform Bacteria* MPN/ml	Virus Isolated†
Effluent	95,000	+
Outfall	75,000	+
20 ft upstream	2,400	+
20 ft downstream	4,300	—

\* Sep. 30, 1954.

† Jul. 27-29, 1954.

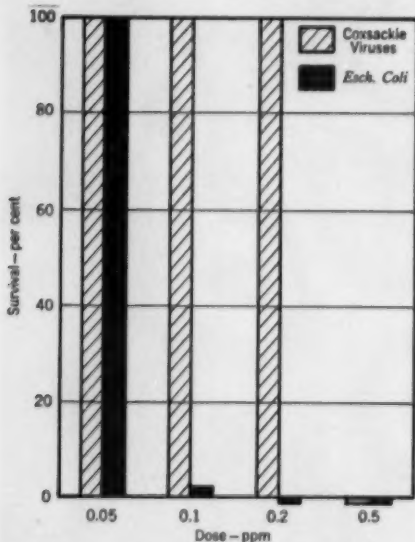


Fig. 7. Survival of Virus and Coliform Bacteria After Chlorination

*Dosages as low as 0.1 ppm chlorine kill Esch. coli, but a concentration greater than 0.2 ppm is necessary to destroy Coxsackie viruses.*

in sewage undergoing dilution in receiving streams. Coxsackie virus isolations were made from swab samples at the outfall of the Albany, N.Y., sewage treatment plant on the Hudson River, along with specimens gathered 20 ft up- and downstream. These were compared with numbers of coliform bacteria in catch samples, collected at

## Conclusion

Although the experiments presented yield additional data concerning the problem under discussion, they are not directly applicable to water works practice, as they were carried out under laboratory conditions rather than on a plant scale. The results suggest that the coliform index is, in general, a valid measure of pollution, both bacterial and viral, and that it is also a reliable indication of the efficiency of treatment processes when the limitations of marginal treatments in the removal of pollution—particularly by enteric viruses—are understood. The

coliform index should be interpreted with discretion and regard for the information available concerning the relative survival rates of the agents in question under conditions of water treatment. The experiments indicate that effective and complete treatment of water is necessary to insure safety from potential pollution by enteric viruses. Marginal treatments are not

also necessary for determining infective densities of viruses in water as compared with coliform microorganisms. It is possible that, although enteric pathogenic viruses are not completely destroyed by present-day water supply treatment, they may be so reduced in numbers that they would not be infective to consumers. Pending further investigation of the problem, it seems

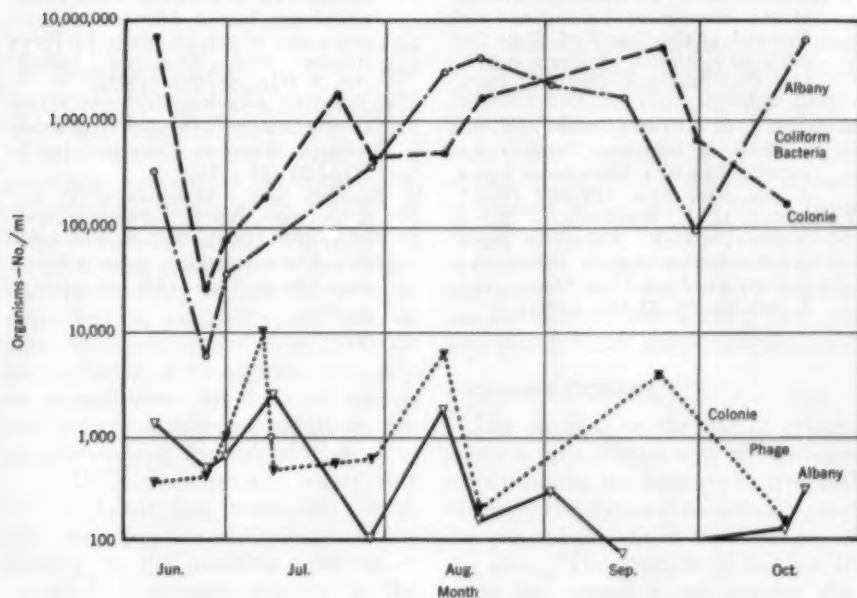


Fig. 8. Coliform-Organism Content of Raw Sewage

*Raw-sewage samples from two treatment plants showed patternless fluctuations in coliform-organism content.*

sufficient, even though they may reduce the density of the coliform group to conform closely with established water quality standards. Much further investigative work on the problem is needed to determine the fundamental significance of the coliform group—compared with viruses and other pathogenic agents—as an indicator of pollution. Epidemiologic studies are

safe to state that the coliform index is still a reliable indicator of significant pollution and of the effectiveness of standard water supply treatment.

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## Ground Water Resources in Texas

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**R. W. Sundstrom**

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*A paper presented on Oct. 20, 1954, at the Southwest Section Meeting, El Paso, Tex., by R. W. Sundstrom, Dist. Engr., Ground Water Branch, US Geological Survey, Austin, Tex. Publication authorized by the Director, US Geological Survey.*

THE future of ground water supplies presents a problem in Texas that is very important to its economy and the well-being of almost every citizen of the state. Assurance of supply is of particular concern to more than 580 municipalities using ground water as their sole source, many thousands of farmers using ground water for irrigation, others living in irrigated areas or dependent on irrigated agriculture for their livelihood, more than 2,000,000 people living in rural areas who rely on ground water for domestic supply, and a large number of industries, including some of the biggest ones.

In 1953, more ground water was used in Texas than in any other state, with the exception of California. According to the available information (gathered from many sources) in the offices of the US Geological Survey and the Texas Board of Water Engrs., the total use of ground water in the state in 1953 is estimated to have been about 7,000,000 acre-ft. The amount now being used is nearly equal to the quantity of surface water used for irrigation, industrial purposes, municipal distribution, and rural domestic supply. Figures on the volume of ground water used for irrigation prior to 1937 are meager. Recent studies indicate that the amount applied varies from less than 1 to more than 3 acre-ft per acre.

The overall consumption of ground water was rather limited until 1939, but since then its employment in irrigation has developed at a tremendous rate. The increase for 1919-49 is shown in Fig. 1. Of the total amount of ground water used in 1953, about 83 per cent was employed for irrigation, about 10 per cent for industrial purposes, about 4 per cent for municipal distribution, and about 3 per cent for rural domestic supply and livestock.

### Increased Demand

The increase in the use of ground water is coincidental with the increase in population, the increase in irrigated farming, the increase in industry, and the general growth of the economy of the state. The drought of the last 10 years has caused a considerable rise in the use of ground water in the irrigated areas and some increase in municipalities.

The statistics of the US Census Bureau over a period of 100 years show that the urban population of Texas has grown at a somewhat steady rate from less than 8,000 in 1850 to more than 4,800,000 in 1950, increasing at the same time from 3½ per cent to 63 per cent of the total population of the state. Figure 2 shows the rise in total population and the distribution in growth among the rural and urban population.

There were no Texas cities of more than 100,000 in 1910. The urban population increased by 60 per cent during the decade from 1940 to 1950, most of the growth being in cities above 10,000. Almost every city in Texas of more than 10,000 since 1940 has experienced difficulties in expanding its public water supply. The town without such a problem has been the exception rather than the rule. Secur-

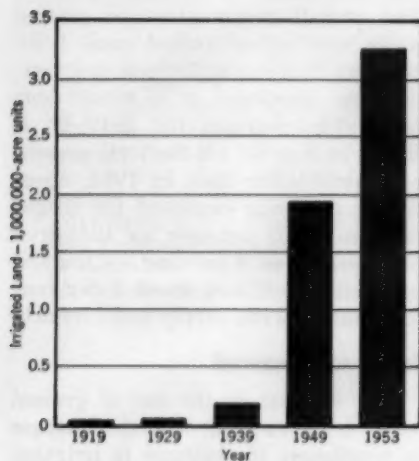


Fig. 1. Increase in Irrigation

The data from 1919 through 1949 were compiled by the US Dept. of Agriculture. The more recent figures were secured from the Texas Board of Water Engineers and the US Geological Survey.

ing sufficient water is also important to people in many of the heavily irrigated areas, the enterprisers involved in the rapid expansion of industries, and the rural farmer who, having gone through 10 years of drought, wonders whether or not he can economically develop ground water to grow crops or water livestock. Texas is becoming water conscious.

### High Plains Area

During 1953, about 6,000 wells were drilled in the High Plains, 35 per cent more than during the preceding 2-year period, 1951-52. More than 85 per cent were drilled in the principal irrigated region of the southern High Plains. By the end of 1953, about 24,500 wells in the High Plains were in use or available for use. Of these, 93 per cent, or 23,000, were in the principal irrigated region. About

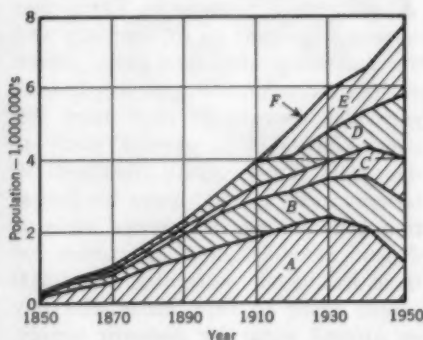


Fig. 2. Population of Texas, 1850-1950

A—rural; B—small town (under 2,500); C—small city (2,500-10,000); D—city (10,000-100,000); E—large city (over 100,000). The upper boundary shows the total population.

1,000 of the remaining 1,500 wells were in the more southerly counties of the High Plains, and about 500 were in the North Plains. The irrigated area in the High Plains region increased from 2,150,000 acres in 1952 to 2,900,000 acres during 1953 (see Fig. 3). Of the total amount of ground water used in 1953, about 4,800,000 acre-ft or 69 per cent was pumped in the High Plains. This estimate is based on the number of acres irrigated, the duty of water per acre

(including rainfall), and pump operating time, obtained from data on consumption of electricity.

Since 1938, the withdrawals of ground water from the Ogallala formation—the principal water-bearing stratum of the High Plains—have increased each year except during those periods (principally 1941) when precipitation was above normal and the demand for water for irrigation was relatively light. Owing in part to drought conditions, the withdrawals of ground water for irrigation, municipal, domestic, and industrial supplies in the High Plains increased from an estimated 3,750,000 acre-ft in 1952 to approximately 4,800,000 acre-ft in 1953, or about 28 per cent. Of the pumpage in 1953, approximately 90 per cent or 4,300,000 acre-ft was withdrawn in the principal irrigated region, an increase of about 1,100,000 acre-ft. About 75,000 acre-ft, or about 2 per cent of the total, was for municipal and industrial use.

In the High Plains from 1938 to the end of 1953, approximately 16,000,000 acre-ft of ground water was taken out, more than 60 per cent of which was pumped during 1950–53. Assuming that water equivalent to about 15 per cent of the total volume of the formation is yielded to wells, the withdrawals in 1953 dewatered 32 million acre-ft of saturated materials, while the withdrawals since 1938 have dewatered about 105 million acre-ft.

Water levels—measured in a network of about 500 observation wells in January, February, and March before pumping begins—provide the basis for estimating the net loss or gain in storage for each year of operation. Because, prior to 1943, irrigation was concentrated in relatively small areas, the declines of the water levels in wells

were not widespread. Since 1943, however, irrigation has expanded in one large district which is the principal irrigated region in the southern High Plains and embraces all or parts of 19 counties. Contours of water level declines in the High Plains during 1953–54 show that the areas in which the recession was 2 ft or more have spread out to form one large area of about 4,200,000 acres. On the basis of the average decline within each county, the total net amount of material dewatered was determined to be 28,000,000 acre-ft. The loss in stor-

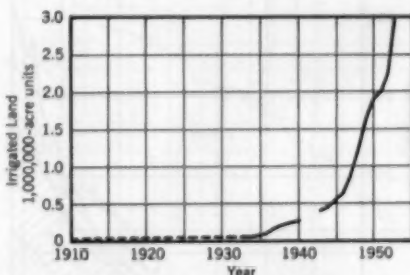


Fig. 3. Irrigation in High Plains Region

*The very light use between 1910 and 1935 has been roughly estimated. No data were available for 1941–42.*

age (assuming a specific yield of 15 per cent) is 4,200,000 acre-ft. This checks very well with the figure of 4,300,000 acre-ft derived from the pumpage inventory. It shows that the assumed figure of 15 per cent for specific yield is very close to the true value and that the great bulk of the water pumped in 1953—as in previous years—came from storage.

It should be emphasized that the decline during 1953–54 represents just one year and that the amount is piled on top of other, smaller, declines in each of the several preceding years.

As the levels recede, it becomes increasingly important to regard the declines in terms of the thickness of the remaining saturated material. Areas where the Ogallala formation is relatively thin can expect to experience diminishing yields sooner than those where the saturated sands are thicker.

Although it is known from available data that the total amount of ground water in storage beneath the High Plains is several hundred million acre-

of surface water from the Canadian River.

Studies of the ground water resources of the High Plains have been under way for many years, but there is still a dire need for additional data to provide a basis for intelligent planning. A fact-finding survey should include:

1. Study of the Ogallala formation, the principal ground water reservoir, and its relation to the occurrence of ground water throughout the High Plains, with emphasis on areas not touched by previous studies.

2. Determination of the approximate thickness of the Ogallala throughout the High Plains.

3. Determination of the approximate amount of ground water that has been removed from storage and the amount that still remains.

4. Study of the capacity of the ground water reservoir to yield water to wells throughout the High Plains.

5. Study of the extent of the present development of ground water in parts of the High Plains where such an investigation has not previously been made.

6. Study of additions to the ground water reservoir through recharge.

7. Determination of the chemical quality of the ground water in parts of the High Plains where such work has not been done.

8. Inventory of the pumpage from the ground water reservoir.

9. Collection of all basic data pertaining to existing wells.

10. Expansion of the present observation well program so that a more accurate estimate of the withdrawal from storage can be obtained each year.

11. Preparation and release to the public of comprehensive reports giving

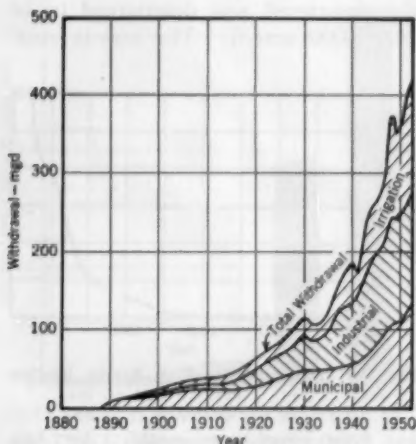


Fig. 4. Ground Water Withdrawal in Houston Coastal Region

*The rate of increase for municipal use is slower than for industrial and irrigation.*

feet, the high rate of withdrawal poses a serious problem not only to some of the irrigators, but also to towns and cities in the area. Planning for the future, the cities of Amarillo and Lubbock have acquired water rights beneath more than 100,000 acres where irrigation is not now being heavily practiced. Other towns are considering similar plans, with still others giving consideration to the development

the results of the studies, along with the useful, basic information collected.

These data are truly essential in determining the potential of the High Plains ground water reservoir and the amount of water available for future use. Similar information—modified as necessary—is needed for other ground water reservoirs in Texas.

As it is impossible in this short paper to discuss even briefly the present development and the potential water-yielding characteristics of the many reservoirs that have received

irrigation use. Figure 5 gives the decline in artesian pressure that has occurred in wells of the most heavily pumped portion of the coastal area since 1932. The cone of artesian-pressure decline has spread as a result of heavy pumping, while the artesian head in the center of the cone has lowered about 300 ft from the original head of the ground water reservoir. A study conducted reveals that—with the exception of problems of over-concentration of pumping and the possibility of eventual salt water intrusion

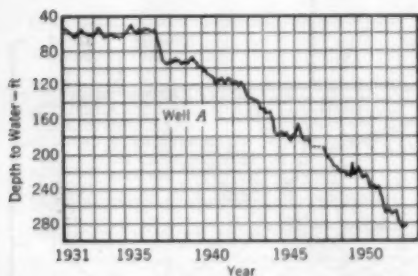


Fig. 5a. Artesian-Pressure Decline in Houston Area

*Well A reaches 836 ft. The depth to the water level was measured from the land surface.*

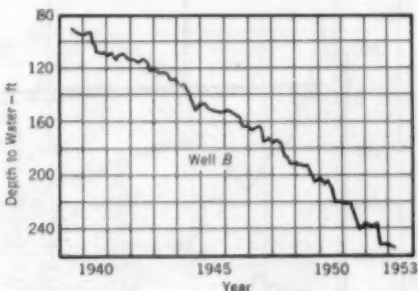


Fig. 5b. Artesian-Pressure Decline in Houston Area

*Well B reaches 1,419 ft. The depth to the water level was measured from the land surface.*

study, the author would like to highlight some of the present developments in such widely scattered areas as Houston, San Antonio, and El Paso.

### Houston Area

Figure 4 shows, for 1889–1953, the rate of development of ground water in the coastal region around Houston. There has been a greatly accelerated rate of ground water development since 1937. The rate of climb in the use of ground water for municipal purposes has been slower than for industrial and

in the southern section—the area as a whole can produce several times the amount of ground water now being withdrawn. A generalized section of the region is presented in Fig. 6 which shows the underlying material and the approximate contact of fresh and salty water.

In most of Harris County, fresh-water sands are as deep as 2,000 ft, a depth of 3,000 ft being reached in a smaller portion. For the purpose of illustrating the amount of fresh ground water beneath Harris County (an area

of 1,730 sq miles), assume that the average depth of fresh water is 2,000 ft and that the porosity of the retaining material ranges from 20 to 40 per cent, averaging 30 per cent. Computation shows that there is more than 2 billion acre-feet of saturated material—more than 650,000,000 acre-ft of water—if the average porosity is 30 per cent. These figures have little value in determining the amount of ground water that could be pumped, owing to the

yield from any ground water reservoir would require a regional development based on sound application of the principles of ground water geology and hydrology.

### San Antonio Area

The growth in the development of ground water by San Antonio (Bexar County) is shown in Fig. 7. At the present time the city is obtaining all of its water from the Edwards limestone.

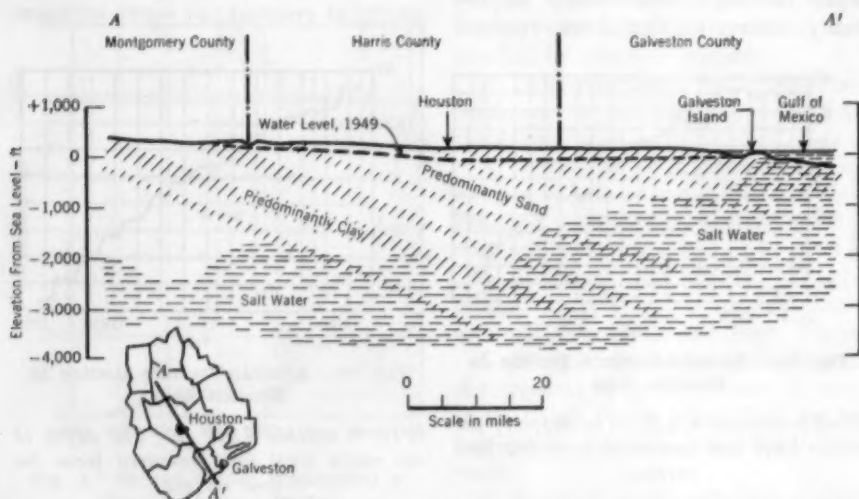


Fig. 6. Generalized Cross Section Showing Principal Water Sands in Houston Area

*The approximate contact of salt and fresh water is shown.*

great depth at which the water occurs. Artesian pressure must be sufficient to force the water from the deeper sands into the wells so that the water can be removed at a higher altitude. The deep sands, however, do have great importance as conduits to the wells. Modern hydrology can be employed in ascertaining within a reasonable degree of accuracy the quantity of water that can be recovered. To get the ultimate

This aquifer forms two immense ground water reservoirs in the San Antonio area. One is an unconfined body of water on the Edwards Plateau in the northern part; the other is an artesian body in the main Balcones fault zone. The hydrologic system on the plateau stores substantial amounts of rainfall, slowly giving it out as spring flow to the perennial streams which have cut their channels into or through the

aquifer. These furnish practically continuous recharge to the artesian reservoir in the Balcones fault zone as they cross long stretches of honeycombed and cavernous limestone, into which the entire normal flow is lost. Thus, the artesian reservoir not only has its own storage facilities, but also receives the benefits of storage and regulation afforded by the system on the Edwards Plateau. In addition, recharge occurs also by direct penetration of rainfall and storm runoff in favorable outcrop localities.



Fig. 7. Ground Water Withdrawal at San Antonio

*The city obtains all of its water from the Edwards limestone aquifer.*

Results of studies suggest that the immense artesian reservoir within the belt of faulting is a common source for the large springs and several thousand wells in the San Antonio region. The discharge of the wells and springs in and near San Antonio—and the water levels in the nonflowing wells throughout the area—vary with the volume of water in the reservoir. Its magnitude is indicated by a uniform temperature and lack of turbidity of the water, as well as by the relation between water level fluctuation in wells, discharge of

wells and springs, and rainfall. Any engineering projects which alter the present rate of recharge to the Edwards limestone aquifer will have a direct effect on the perennial yield of ground water in the San Antonio area and elsewhere along the fault zone.

During the 20 years following 1928 the stage of the artesian reservoir around San Antonio was in approximate equilibrium. The average rate of withdrawal was about 110 mgd. A

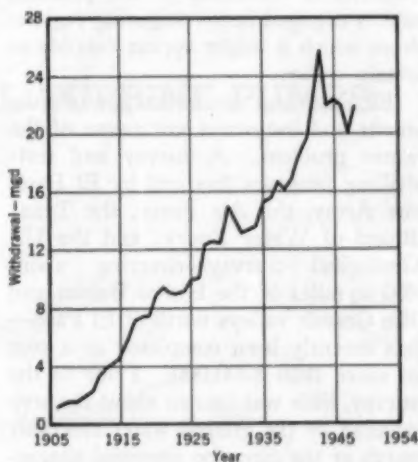


Fig. 8. Ground Water Withdrawal in El Paso Area

*The rate of withdrawal from the aquifer at present exceeds the rate of recharge.*

large spring (Comal Springs) in a nearby county had an average discharge of about 210 mgd. Some additional water probably remained unaccounted for. Thus, it is estimated that—with average rainfall on favorable recharge localities—the perennial yield of the reservoir in central Bexar County and an adjacent part of Comal County is not less than about 320–330 mgd. Information gathered during the

present prolonged drought indicates the yield is less under conditions of extreme dryness.

A recent study of areas suitable for irrigation in Bexar County and the nearby counties of Uvalde and Medina indicates that irrigation from the same reservoir which supplies San Antonio might be developed to an extent where the withdrawal would be greater than the amount of surplus water passing the city toward Comal Springs. San Antonio is conscious of the problem and is engaged in investigating regions from which it might appear feasible to obtain water.

El Paso and its military establishments and industries are aware of the water problem. A survey and test-drilling program financed by El Paso, the Army, the Air Force, the Texas Board of Water Engrs., and the US Geological Survey—covering about 800 sq miles of the Hueco Bolson and Rio Grande valleys north of El Paso—has recently been completed at a cost of more than \$200,000. Prior to the survey, little was known about the area covered by the ground water reservoir north of the city, the chemical character of the ground water, and the approximate amount in storage. El Paso has known for some time that the rate of withdrawal from the reservoir has exceeded the rate of recharge to the well field in the Hueco Bolson. The city is attempting to acquire rights to additional ground water outside the

area. The amount of ground water withdrawal around El Paso for 1905-54 is shown in Fig. 8.

### Conclusion

Problems of present and future ground water supplies are not uncommon in areas other than the four discussed. Locally, in parts of all the different ground water areas west of the 30-in rainfall belt, water is being removed at a rate greater than replenishment where heavy development has taken place for irrigation, public, or industrial use. The fact that ground water is being mined does not indicate that there is an immediate ground water difficulty in all places. It is known that many hundreds of millions of acre-feet of usable ground water still remain in storage in some of the larger reservoirs. Further, in certain areas—particularly in the lower coastal plain—large reserves of ground water remain undeveloped.

For the future, the author cannot stress too strongly the need for a clear, accurate appraisal of all the ground water resources as a basis in planning for intelligent development. Texas not only ranks second in ground water use, but it is also one of the top-ranking states in total ground water supply. Proper planning and development by those using ground water is necessary to assure the ultimate possible supply in times to come.



**American Standard Specifications**  
*for*  
**DEEP WELL VERTICAL TURBINE PUMPS**

*Approved by American Standards Association May 11, 1955*

***Sponsored and Published by***  
**AMERICAN WATER WORKS ASSOCIATION**  
*Incorporated*

**521 Fifth Avenue, New York 17, N.Y.**

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## American Standard Specifications for Deep Well Vertical Turbine Pumps

### Section 1—Scope and Purpose

This specification is recommended as a guide for the deep well turbine pump user in selecting new equipment. The suggested standards are to be considered as a minimum requirement for a first-quality deep well turbine pump, but do not preclude the use of more elaborate specifications on the part of either user or manufacturer, nor is it the intent to restrict the use of any

equipment not meeting the requirements of this specification should the user not consider such compliance necessary.

This specification is applicable primarily to pumps that are constructed of accepted standard materials of the best quality and workmanship, and handle cold, clear water, usually from an underground well.

### Section 2—Definitions

2.1. *A vertical turbine pump* is a vertical-shaft centrifugal or mixed-flow pump with rotating impeller or impellers, with discharge from the pumping element coaxial with the shaft. The pumping element is suspended by the conductor system which encloses a system of vertical shafting used to transmit power to the impellers, the prime mover being external to the flow stream. The unit is used for pumping from open pools or closed suction systems. A basic pump consists of three elements, defined as follows:

2.1.1. *The pump bowl assembly* is either a single or multistage, centrifugal or mixed-flow vertical pump with discharge coaxial with the shaft. It has open, semiopen, or enclosed impellers. Assemblies are constructed for use with either open or enclosed line shafts.

2.1.2. *The column and shaft assembly* consists of the column pipe which

suspends the pump bowl assembly from the head assembly and serves as a conductor for the fluid from the pump bowl assembly to the discharge elbow. Contained within the column pipe is the line shaft which transmits the power from the driver to the pump shaft. The line shaft is supported throughout its length by means of bearings and may be enclosed in a shaft-enclosing tube and generally lubricated with oil, or it may be open and lubricated with the fluid being pumped.

2.1.3. *The head assembly* consists of the base from which the column and shaft assembly and the bowl assembly are suspended, the discharge elbow which directs the fluid into the desired piping system, and the driver.

2.1.3.1. *The driver* is the mechanism mounted on the discharge head which transmits the power to the top shaft. It contains means for impeller

adjustment and provides a bearing to carry the thrust load. It may or may not be a prime mover.

2.1.3.2. *In underground discharge*, the discharge elbow is separated from the head assembly and installed in the column pipe at the desired distance below the head assembly.

2.2. *Types of drivers* are defined as follows:

2.2.1. *The vertical hollow-shaft motor drive* is an electric motor having a motor shaft which has been bored on the center of its axis to receive the top shaft of the pump. Impeller adjustment is made at the upper end of the motor, and a means to carry the thrust on a bearing within the motor is provided.

2.2.2. *The vertical hollow-shaft right-angle gear drive* is a gear mechanism having a shaft which has been bored on the center of its axis to receive the top shaft of the pump. The horizontal shaft of a gear drive receives its power from the prime mover and, through a pair of bevel gears, transmits it to the top shaft. Impeller adjustment is made at the upper end of the gear drive, and a means to carry the thrust on a bearing within the gear drive is provided.

2.2.3. *The vertical hollow-shaft belted drive* is a flat- or V-belt driven mechanism having a shaft which has been bored on the center of its axis to receive the top shaft of the pump. Impeller adjustment is made at the upper end of the belted drive, and a means to carry the thrust on a bearing within the belted drive is provided.

2.2.4. *The flexible-coupling drive* is a mechanism having a thrust bearing capable of carrying the pump thrust, providing means of impeller adjustment, and having a flexible coupling. The top of this driver is designed to mount solid-shaft prime movers, in-

cluding electric motors, steam turbines, radial engines, or any other type of prime mover having a solid shaft and suitable for mounting with the shaft in a vertical position.

2.2.5. *The combination drive* includes means for operating the pump with two or more drivers.

2.3. *The datum* shall be taken as the elevation of that surface from which the weight of the pump is supported. This is normally the elevation of the underside of the discharge head or head base plate.

2.4. *The setting* is the nominal distance in feet from the datum to the column pipe connection at the bowl assembly.

2.5. *The static water level* is the vertical distance in feet from the datum to the level of the free pool while no water is being drawn from the pool.

2.6. *The pumping water level* is the vertical distance in feet from the datum to the level of the free pool while the specified fluid flow is being drawn from the pool.

2.7. *Drawdown* is the difference in feet between the pumping water level and the static water level.

2.8. *Specific yield*, expressed in gpm (US gallons per minute) per foot of drawdown, is the rate of flow from the free pool, divided by the drawdown.

2.9. *The capacity of the pump* is the volume rate of flow ( $Q$ ), expressed in gpm, produced by the pump, calculated for specified conditions.

2.10. *The pump speed of rotation* ( $N$ ) is the rate of rotation of the pump shaft, expressed in rpm (revolutions per minute).

2.11. *Head* is a quantity used to express a form (or combinations of forms) of the energy content of the liquid per unit weight of the liquid, referred to any arbitrary datum. In

terms of foot-pounds of energy per pound of liquid, all head quantities have the dimension of feet of liquid.

2.11.1. *Head below datum ( $h_b$ )* is the vertical distance in feet between the datum and the pumping water level.

2.11.2. *Head above datum ( $h_a$ )* is the head measured above the datum, expressed in feet of liquid, plus the velocity head (Sec. 2.11.3) at the point of measurement.

2.11.3. *Velocity head ( $h_v$ )* is the kinetic energy per unit weight of the liquid at a given section. Velocity head is specifically defined by the expression:

$$h_v = \frac{v^2}{2g}$$

2.11.4. *Suction head ( $h_s$ )* is the algebraic sum of the pressure head (measured at the elevation of the suction case lower connection) and the velocity head at that point. The value of the suction head is not required when the surface of the liquid being pumped is exposed to atmospheric pressure.

2.11.5. *Pump total head ( $H$ )* is the bowl assembly head (Sec. 2.11.6) minus the column loss (Sec. 2.12) and discharge head loss. This is the head generally called for in pump specifications.

2.11.5.1. *On open-suction installations*, it is the algebraic sum of the head below datum and the head above datum.

2.11.5.2. *On closed-suction installations*, it is the algebraic sum of the suction head, the distance between the suction case flange and the datum, and the head above datum.

2.11.6. *Bowl assembly head ( $h_1$ )* is the energy imparted to the liquid by the pump (expressed in foot-pounds per pound of liquid). It is the head of a pump installed with a minimum

length of column and shaft, as in the manufacturer's laboratory.

2.11.6.1. *On open-suction installations*, it is the algebraic sum of the head below datum and the head above datum.

2.11.6.2. *On closed-suction installations*, it is the algebraic sum of the suction head, the distance between the suction case flange and the datum, and the head above datum.

2.12. *The column loss ( $h_c$ )* is the value of the head loss (expressed in feet) due to the flow friction in the column pipe. This value is subtracted from the bowl assembly head to predict the pump total head.

2.13. *The line shaft loss ( $hp_1$ )* is the power (expressed in horsepower) required because of the rotation friction of the line shaft. This value is added to the bowl assembly input (Sec. 2.14.3) to predict the pump input (Sec. 2.14.1).

2.14. *Power* is expressed in units of horsepower. One horsepower is equivalent to 550 ft-lb per second, 33,000 ft-lb per minute, 2,545 Btu per hour, or 0.746 kw.

2.14.1. *Pump input* is the power delivered to the line shaft, expressed in horsepower.

2.14.2. *Driver power input* is the power input to the driver, expressed in horsepower.

2.14.3. *Bowl assembly input* is the power delivered to the pump shaft, expressed in horsepower. It is the pump input of a pump installed with a minimum of column and shaft, as in the manufacturer's laboratory.

2.15. *Output* is defined as follows:

2.15.1. *Pump output* is defined as  $\frac{QH}{3,960}$  for water having a specific weight of 62.4 lb per cubic foot. It is expressed in horsepower.

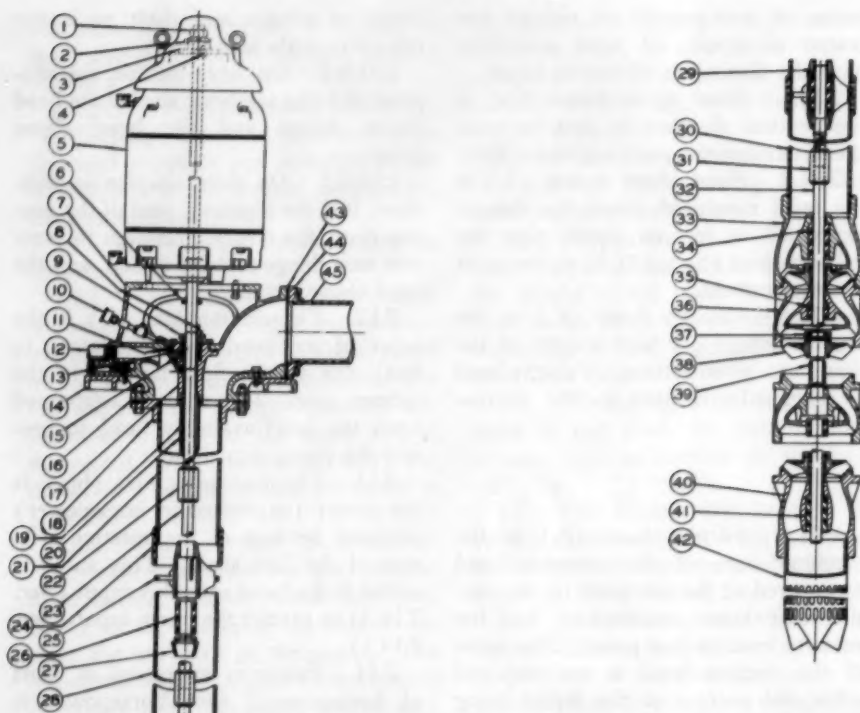


Fig. 3.1a. Open Line Shaft Pump (Surface Discharge, Threaded Column and Bowls)

2.15.2. *Bowl output* is defined as  $\frac{Qh_1}{3,960}$  for water having a specific weight of 62.4 lb per cubic foot. It is expressed in horsepower.

2.16. *Efficiency* is defined as follows:

2.16.1. *Pump efficiency* ( $\eta_p$ ) is the ratio of pump output to pump input, expressed in per cent.

2.16.2. *Overall efficiency* ( $\eta$ ) is the ratio of pump output to driver power input, expressed in per cent.

2.16.3. *Driver efficiency* ( $\eta_d$ ) is the ratio of the driver output to the driver input, expressed in per cent.

2.16.4. *Bowl assembly efficiency* ( $\eta_1$ ), is the ratio of the bowl output to the bowl assembly input, expressed in per cent.

2.17. Additional definitions of terms generally applicable to the pumping of fluids other than water may be found in the American Society of Mechanical Engrs. "Power Test Code for Centrifugal and Rotary Pumps" and may be used when appropriate.

### Section 3—Nomenclature

#### Sec. 3.1—Standard Nomenclature

Table 3.1 lists the name of the part, together with its function and typical

material. The material listed is intended to be typical only and does not constitute a recommendation. The

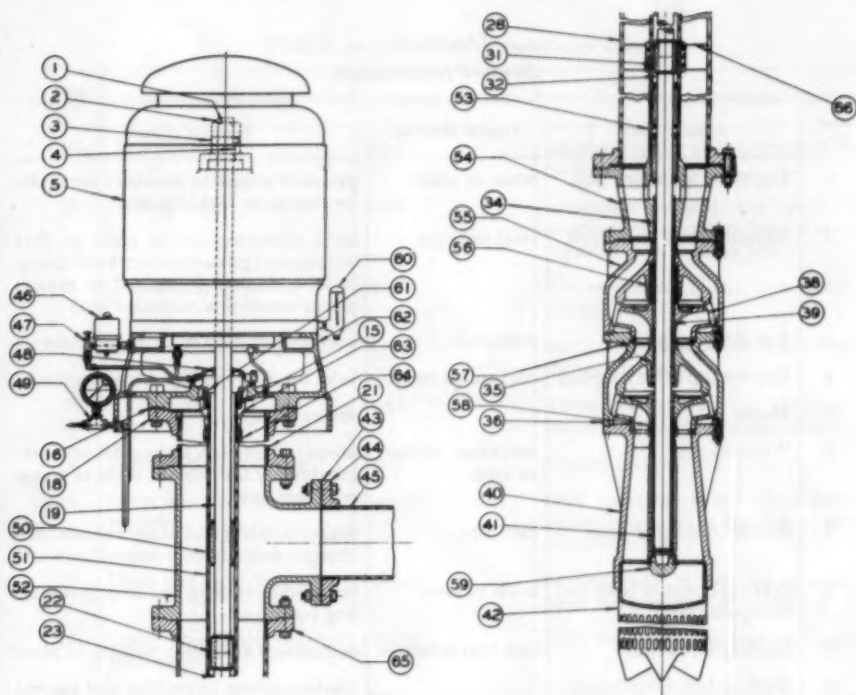


Fig. 3.1b. Enclosed Line Shaft Pump (Underground Discharge, Flanged Column and Bowls)

part number refers to the numbers in Fig. 3.1.

### Sec. 3.2—Order Form

A recommended specification form for use in purchasing deep well turbine pumps is given in Table 3.2.

## Section 4—General Specifications

### Sec. 4.1—General

4.1.1. *Descriptive matter.* The bidder shall submit, with his proposal, sufficient descriptive material or outline drawings to demonstrate compliance with these specifications, and a performance curve showing pump total head, pump input horsepower, and pump efficiency over the specified head range for the installed pump.

4.1.2. *Sanitary codes.* The pump shall conform to the sanitary codes

governing the installation. The purchaser shall furnish, as a part of these specifications, all information necessary for the construction of the pump to meet these requirements.

4.1.3. *Pump base.* A suitable base of cast iron or fabricated steel shall be provided for mounting the driver and supporting the pump column. The (aboveground or below ground) discharge outlet shall be flanged, or a nipple with a companion flange shall be

TABLE 3.1  
Standard Nomenclature

Part No.	Name of Part	Typical Material	Function of Part
1	Top shaft adjusting nut	brass or steel	means of adjusting impellers vertically by raising or lowering shaft
2	Adjusting-nut lock screw	steel or brass	locks adjusting nut in place so that adjustment cannot change while pump is in operation (furnished as simple pin or screwed or threaded pin)
3	Top drive coupling	semisteel	couples top shaft with motor rotor
4	Key for top drive coupling	cold-rolled steel	keys top shaft to top drive coupling
5	Motor		drives pump
6	Water slinger	neoprene, rubber, or steel	keeps packing box leakage from shooting directly into hollow shaft of motor or driver unit
7	Surface discharge head	cast iron	supports driver and pump column; discharges water from pump column
8	Stuffing box stud bolts and hexagonal nuts	brass or steel	fastened in stuffing box to adjust stuffing box gland
9	Stuffing box gland	cast iron or bronze	compresses and holds packing in place
10	Stuffing box lubrication fittings		conduct grease to packing and journal bearing
11	Stuffing box gasket		placed under seat of packing containers to prevent leakage
12	Prelubrication fittings		conduct water to keep water-lubricated bearings wet during starting cycle
13	Top shaft sleeve	Monel or stainless steel	sleeve operating within packed area in top shaft on open line shaft pumps
14	Head base plate	cast iron or steel	plate or casting that supports discharge head and may become permanent part of foundation after initial installation
15	Packing		flexible material which can be compressed by stuffing box gland in stuffing box so as to prevent leakage of fluid being pumped
16	Top column flange gasket		seals joint between flange faces
17	Stuffing box	cast iron	guides shaft and holds packing
18	Top column flange	cast iron	couples column to discharge head

TABLE 3.1—Standard Nomenclature (contd.)

Part No.	Name of Part	Typical Material	Function of Part
19	Top shaft	steel	coupled to line shaft; connects latter to driver
20	Stilling tube	steel	suspended around top shaft from packing box to reduce flow of abrasive material into packing box
21	Top column pipe	steel	first section of column pipe below discharge
22	Line shaft coupling	steel	used to join all sections of line shafting throughout unit
23	Line shaft	steel	Those sections of line shafting between top shaft and pump shaft
24	Column pipe coupling	steel	couple sections of column pipe
25	Open line shaft bearing retainer	bronze	used to support line shaft bearing; generally located at end of each section of column pipe
26	Open line shaft bearing	rubber	bearing held in bearing retainer to guide line shafting of pump
27	Open line shaft bearing retainer cap	bronze	locks bearing within bearing retainer
28	Column pipe	steel	column pipe between top column and bottom column pipe; usually made of standard steel pipe
29	Open line shaft sleeve	Monel or stainless steel	sleeve operating as journal for bearings
30	Bottom column pipe	steel	first section of column immediately above discharge case or discharge bowl
31	Pump shaft coupling	steel	connects bottom shaft to impeller shaft; may be tapped with two different thread diameters
32	Pump shaft	stainless steel	supports impellers; coupled to line shaft
33	Discharge bowl	cast iron	receives flow from top impeller and guides it to pump column
34	Top bowl bearing	bronze or rubber	supports portion of pump shaft
35	Intermediate bowl bearing	bronze or rubber	supports portion of pump shaft
36	Intermediate bowl	cast iron	guides flow received from impeller to next impeller above
37	Impeller collet lock nut	bronze	used to pull impeller on collet; locks collet in place

TABLE 3.1—Standard Nomenclature (contd.)

Part No.	Name of Part	Typical Material	Function of Part
38	Impeller	bronze or cast iron	pumping element; receives water and impels it centrifugally to bowl passage
39	Impeller lock collet	steel	locks impeller to shaft
40	Suction bowl	cast iron	receives water from well; guides to first impeller
41	Suction bowl bearing	bronze	supports bottom portion of pump shaft
42	Strainer	galvanized steel or bronze	keeps large foreign material out of pumps
43	Discharge companion flange gasket	rubberized cloth or rubber	seals joints between surface discharge head or underground elbow and companion flange
44	Discharge companion flange	cast iron	connects discharge pipe to integrally cast flanges on discharge head or underground discharge elbow
45	Discharge pipe	steel	conducts water away from pump.
46	Solenoid oil valve		starts oil flow to line shaft bearings when motor is started
47	Sight-feed oil valve		means of adjusting oil flow to line shaft bearings
48	Tubing tension nut cap	cast iron	covers top of oil tube to prevent entrance of dust
49	Water level indicator assembly		determines water level in well
50	Enclosed line shaft bearing	bronze	guides and supports shaft section; may couple connecting sections of enclosing tube
51	Shaft enclosing tube	steel	encloses line shaft
52	Underground discharge tee	cast iron	changes flow from vertical to horizontal when discharge is below surface; also forms part of column
53	Tubing adapter	cast iron or steel	encloses shaft; adapts standard tube size to off-standard tube size
54	Discharge case	cast iron	guides flow to pump column
55	Top bowl	cast iron	receives flow from top impeller and guides it to discharge case
56	Bypass seal		restricts leakage from bowls to oil tube; seals off bowl passages from enclosing tube

TABLE 3.1—Standard Nomenclature (contd.)

Part No.	Name of Part	Typical Material	Function of Part
57	Impeller seal ring	rubber, bronze, or hardened steel	provides water seal at impeller
58	Suction case sand collar	bronze	prevents sand from entering suction case bearing
59	Suction case plug	black iron	plugs suction case grease container
60	Oil gage assembly for motor bearings		shows level of oil in motor oil reservoir
61	Packing follower	cast iron	tightens packing around enclosing tube
62	Underground discharge head	cast iron	supports motor above foundation when discharge is below surface
63	Tubing tension nut	semisteel	maintains tension on shaft enclosing tube
64	Lock nut for tubing tension nut	cast brass	locks tubing nut
65	Column flange	steel	joins sections of column pipe
66	Enclosing tube stabilizer	bronze or rubber	stabilizes shaft enclosing tube

furnished for a 125-lb ASA standard connection, as specified.

4.1.4. *Driver.* With electric power, the motor shall be of the full-voltage starting, vertical hollow-shaft squirrel-cage induction type, and shall comply with ASA Specification C70. The connection to the pump shaft shall be through a coupling or clutch in the motor head. The motor shall be of the proper size to drive the pump continuously over the specified operating range without the load exceeding the service factor. The motor shall be rated as dripproof 40°C rise design with 1.15 service factor. (Standard motor voltages are 208, 220, 440, 550, 2,300.)

With a gasoline or diesel engine drive, the power shall be applied to the pump shaft through a right-angle gear set. The connection to the ver-

tical shaft shall be through a coupling or clutch in the gear head. The horizontal shaft shall rotate in the same direction as the engine drive, and shall be connected to the engine by a flexible shaft type coupling.

An optional method of driving, for an engine or horizontal electric motor, shall be a belt head—either a flat belt on a modified cylindrical pulley, or a V-belt on a V-groove pulley.

Rotation of the vertical shaft shall be counterclockwise when viewed from above.

A thrust bearing of ample capacity to carry the weight of all rotating parts plus the hydraulic thrust shall be incorporated into the driver as an integral part of it. The bearing shall be of such a size that the average life rating is no less than 5 years' continuous operation.

TABLE 3.2

*Suggested Specification Form for the Purchase of ASA Deep Well Vertical Turbine Pumps*

- 
1. Purchaser.....
  2. Address .....
  3. Installation site.....
  4. Job No. .... Item No. .... Quote No. ....
  - P.O. No. ....
  5. No. required..... By ..... Date.....
  6. Driver: Electric motor ..... Right-angle gear ..... Belt.....
  - Engine .....

*Pump Operating Conditions*

7. Capacity ..... gpm; Maximum speed ..... rpm
- Elevation at site ..... ft
8. Pumping level below ground level at rated capacity ..... ft
9. Pumping head above ground level, including discharge pipe friction ..... ft
10. Rated total pump head (Lines 8 plus 9, above) ..... ft
11. Operating range: Minimum total head ..... ft
- Maximum total head ..... ft
12. Pump setting ..... ft

*Description of Well*

13. Minimum inside diameter of well or casing ..... in., to a depth of ..... ft
14. Total depth of well ..... ft
15. Well straight to a depth of ..... ft (a well is considered straight if a 20-ft long cylinder equal to a bowl diameter will not bind when lowered to a depth equal to the pump setting)
16. Static water level below ground surface ..... ft
17. Pumping drawdown ..... ft at ..... gpm
18. Well developed to ..... per cent of rated pump capacity
19. Sand in water: None ..... Average ..... High ..... Unknown .....
20. Gas in water: None ..... Average ..... High ..... Unknown .....
21. Water corrosive: Yes ..... No .....
22. Corrosive substances .....
- Materials to resist corrosion .....

*Driver Data*

23. Electric power available .....: Maximum horsepower .....
- Volts..... Cycles ..... Phase .....
24. Other driver available .....: Maximum horsepower .....
- (Gas) (Gasoline) (Diesel) engine; Drive: (Direct) (Belt)
25. V-belt size .....: Groove type sheave ..... diameter
- Flat belt ..... width; Pulley diameter .....

*Connections and Accessories*

26. Discharge flange ..... in., 125-lb ASA Standard threaded companion flange above-ground standard (if underground discharge desired, centerline shall be ..... ft below ground level)
27. Strainer required: Yes ..... No .....
28. Solenoid oiler required: Yes ..... No ..... Voltage available .....
29. Prelube water tank required: Yes ..... No .....
30. Automatic controls required: Time delay relay ..... Float switch .....

*Pumps are to be furnished in accordance with ASA Specification B58, with the following exceptions:*

---

#### 4.1.5. Suction pipe and strainer.

A strainer, if required, shall have a net inlet area equal to at least two times the suction pipe area. The maximum opening shall be not more than 75 per cent of the minimum opening of the water passage through the bowl or impeller.

### Sec. 4.2—Oil-lubricated Pump and Column

4.2.1. *Pump bowls.* The castings shall be free of blow holes, sand holes, and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated capacity or  $1\frac{1}{2}$  times shutoff head, whichever is greater. Bowls may be equipped with replaceable seal rings on the suction side of enclosed impellers. The discharge case shall be provided with a means of reducing to a minimum the leakage of water into the shaft enclosing tube, and must have bypass ports of sufficient area to permit the escape of water that leaks through the seal or bushing.

4.2.2. *Impellers.* The impellers shall be of the enclosed or semiopen type, statically balanced. They shall be securely fastened to the impeller shaft with keys, taper bushings, or lock nuts. They shall be adjustable vertically by means of a nut in the motor head.

4.2.3. *Pump shaft.* The pump shaft shall be turned and ground, and it shall be supported by bearings above and below each impeller. The size of the shaft shall be determined by the calculation procedures and stress values outlined in ASA B17c-1927, "Code for Design of Transmission Shafting."

The maximum intensity of shear of the shaft material shall be calculated by formula from ASA B17c-1927.

For this specific application with steady loads of diffuser type pumps with shaft in tension due to hydraulic thrust ( $\alpha = 1$ ;  $K_t = 1$ ;  $M = 0$ ;  $K = 1$ ):

$$D^3 = \frac{16}{\pi P_t} \sqrt{\left(\frac{FD}{8}\right)^2 + \left(\frac{396,000P}{2\pi N}\right)^2}$$

or:

$$P_t = \sqrt{\left(\frac{2F}{\pi D^2}\right)^2 + \left(\frac{321,000P}{ND^3}\right)^2}$$

in which  $D$  is diameter (in inches) of shaft at root of threads or any similar undercut;  $F$  is axial thrust on shaft, in pounds;  $N$  is number of revolutions per minute;  $P$  is horsepower; and  $P_t$  is combined shear stress, in pounds per square inch.

The maximum combined shear stress ( $P_t$ ) shall not exceed 30 per cent of the elastic limit in tension or be more than 18 per cent of the ultimate tensile strength of the shafting steel used.

The straightness and machining tolerances shall be the same as those given under "Line Shafts" (Sec. 4.2.4).

4.2.4. *Line shafts.* The line shafts shall be ground, of carbon steel, and of the size that will conform to the ratings in Table 5.5. The shaft shall be furnished in interchangeable sections having a nominal length of 10 ft. To insure accurate alignment of the shafts, they shall be straight within 0.005-in. total indicator reading for a 10-ft section; the butting faces shall be machined square to the axis of the shaft; the maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.002 in. in 6 in. The line shaft shall be coupled with steel couplings, which shall be designed with a safety factor of  $1\frac{1}{2}$  times the shaft safety factor and shall have a left-hand thread to tighten during pump operation.

4.2.5. *Line shaft bearings.* The line shaft bearings, which also have integral couplings, shall be spaced not more than 5 ft apart. The maximum angle error of the thread axis to the bore axis shall be within 0.001 in. per inch of thread length. The concentricity of the bore to the threads shall be within 0.005-in. total indicator reading. The bearings must contain oil grooves or a separate bypass hole which will readily allow the oil to flow through and lubricate the bearings below.

4.2.6. *Shaft enclosing tube.* The shaft enclosing tube shall be made of extra-strong steel pipe in interchangeable sections not more than 5 ft in length. Each section shall be machined and threaded relative to accurately prepared diameters at extreme ends of the tube or by means of locating devices mounted thereon. The ends of the enclosing tube shall be square with the axis and shall butt to insure accurate alignment. The maximum angle error of the thread axis relative to the bore axis shall be 0.001 in. per inch of thread length. The enclosing tube shall be stabilized in the column pipe by stabilizers.

4.2.7. *Discharge column pipe.* The pipe size shall be such that the friction loss will not exceed 5 ft per 100 ft, based on the rated capacity of the pump. The pipe shall be furnished in interchangeable sections having a nominal length of 10 ft; shall be of standard weight, conforming to the specifications in Table 5.1; and shall be connected by threaded sleeve type couplings. The ends of each section of pipe may be faced parallel and machined with threads to permit ends to butt, or they may be fixed with ASA standard tapered pipe threads.

4.2.8. *Discharge head assembly.* At the surface discharge head or underground discharge head, a proper lubrication system must be installed; it shall consist of a manually operated sight-feed drip lubricator and an oil reservoir of ample capacity, constructed as an integral part of the head or as a separate auxiliary unit. A tubing tension nut shall be installed in the head to allow tension to be placed on the shaft enclosing tube. Provision must be made for sealing off the threads at the tension nut.

### **Sec. 4.3—Water-lubricated Pump and Column**

4.3.1. *Pump bowls.* The castings shall be free of blow holes, sand holes, and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated capacity or  $1\frac{1}{2}$  times shutoff head, whichever is greater. Bowls may be equipped with replaceable seal rings on the suction side of enclosed impellers.

4.3.2. *Impellers.* The impellers shall be of the enclosed or semiopen type, statically balanced. They shall be securely fastened to the impeller shaft with keys, taper bushings, or lock nuts. They shall be adjustable vertically by means of a nut in the motor head.

4.3.3. *Pump shaft.* The pump shaft shall be turned and ground, and it shall be supported by bearings above and below each impeller. The size of the shaft shall be determined by the calculation procedures and stress values outlined in ASA B17c-1927, "Code for Design of Transmission Shafting."

The maximum intensity of shear of the shaft material shall be calculated by formula from ASA B17c-1927.

For this specific application with steady loads of diffuser type pumps with shaft in tension due to hydraulic thrust ( $\alpha=1$ ;  $K_t=1$ ;  $M=0$ ;  $K=1$ ):

$$D^3 = \frac{16}{\pi P_t} \sqrt{\left(\frac{FD}{8}\right)^2 + \left(\frac{396,000P}{2\pi N}\right)^2}$$

or:

$$P_t = \sqrt{\left(\frac{2F}{\pi D^3}\right)^2 + \left(\frac{321,000P}{ND^3}\right)^2}$$

in which  $D$  is diameter (in inches) of shaft at root of threads or any similar undercut;  $F$  is axial thrust on shaft, in pounds;  $N$  is number of revolutions per minute;  $P$  is horsepower; and  $P_t$  is combined shear stress, in pounds per square inch.

The maximum combined shear stress ( $P_t$ ) shall not exceed 30 per cent of the elastic limit in tension or be more than 18 per cent of the ultimate tensile strength of the shafting steel used.

The straightness and machining tolerances shall be the same as given under "Line Shafts" (Sec. 4.3.4).

**4.3.4. Line shafts.** The line shafts shall be ground, of carbon steel, and of the size that will conform to the ratings in Table 5.5. The shaft shall be furnished in interchangeable sections having a nominal length of 10 ft. To insure accurate alignment of the shafts, they shall be straight within 0.005-in. total indicator reading for a 10-ft section; the butting faces shall be machined square to the axis of the shaft; the maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.002 in. in 6 in. The line shaft shall be coupled with steel couplings, which shall be designed with a safety factor of  $1\frac{1}{2}$  times the shaft safety factor and shall

have a left-hand thread to tighten during pump operation. The shaft shall be provided with a noncorrosive wearing surface at the location of each guide bearing.

**4.3.5. Line shaft bearings.** The shaft bearings shall be designed for vertical turbine pump service, to be lubricated by the liquid pumped. They shall be mounted in bearing retainers which shall be held in position in the column couplings by means of the butted ends of the column pipes. The bearings shall be spaced at intervals of not more than 10 ft.

**4.3.6. Discharge column pipe.** The pipe size shall be such that the friction loss will not exceed 5 ft per 100 ft, based on the rated capacity of the pump. The pipe shall be furnished in interchangeable sections having a nominal length of 10 ft; shall be of standard weight, conforming to the specifications in Table 5.1; and shall be connected with threaded sleeve type couplings. The ends of each section of column pipe shall be faced parallel and the threads machined to such a degree that the ends will butt, to insure proper alignment when assembled.

**4.3.7. Discharge head assembly.** The pump shall be provided with a discharge head of the surface or underground type, as required, and shall be provided with a shaft packing box and a renewable bronze bushing. The head shall also include a prelubrication connection to wet down the line shaft bearings adequately before starting the pump.

**4.3.8. Prelubrication.** Provisions shall be made by the manufacturer to prelubricate line shaft bearings adequately before the pump is started, on installations with a setting of more than 50 ft.

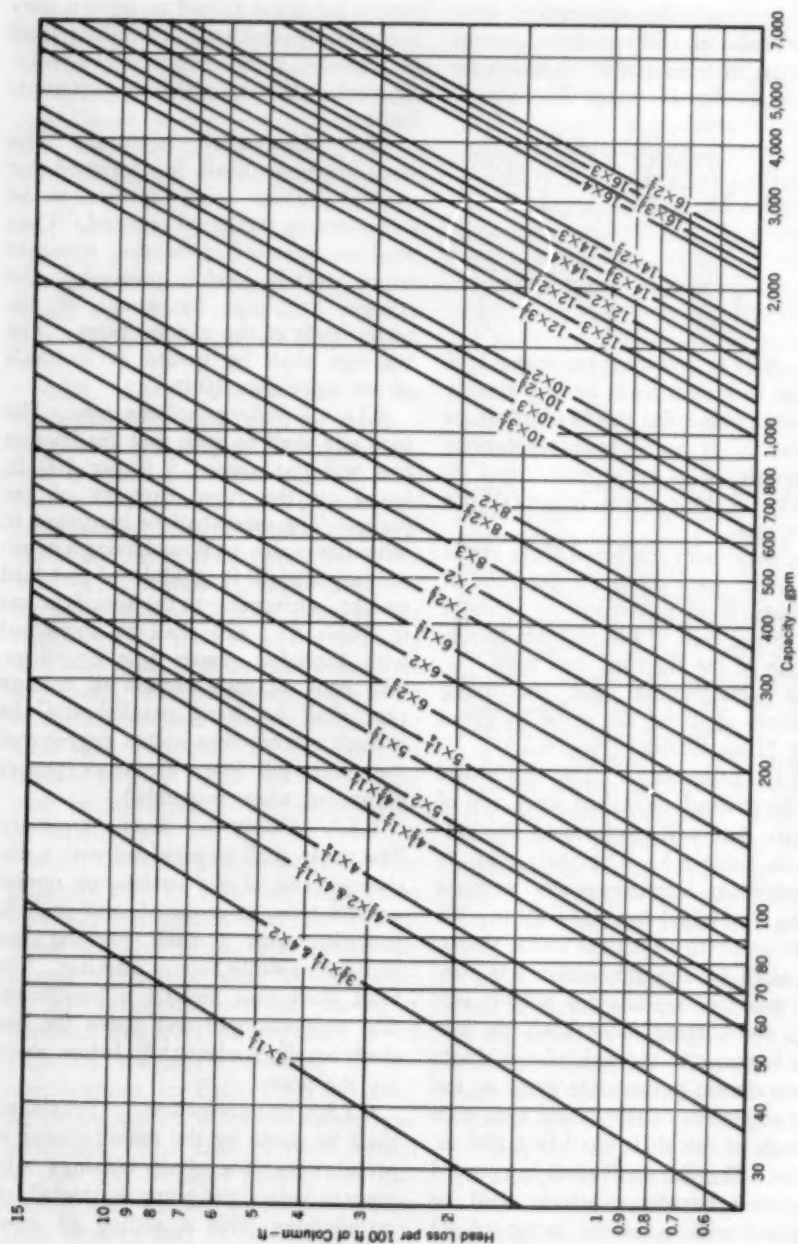


Fig. 5.2. Friction Loss Chart for Standard Pipe Column (See Note on Facing Page)

Where manual control is used and a source of fresh water under pressure is not available, a prelubricating tank, with the necessary valves and fittings to connect it to the pump, shall be provided. The size of the tank shall be adequate to permit thorough wetting of all the line shaft bearings before the power is applied, with an adequate reserve for repeating the process in the event that the pump does not start the first time for any reason.

If an automatic system is used, bypass fittings or other suitable means

shall be provided to bring the prelubricating water from ahead of the check valve into the prelubricating opening of the discharge head. This normally implies the use of a time delay relay in the starting system and a solenoid valve in the prelubricating line.

4.3.9. *Ratchets.* Water-lubricated deep well turbine pumps having a setting of 50 ft or more shall be provided with a nonreverse mechanism in the motor to protect the line shaft bearings from reverse rotation when the power is interrupted and the water empties from the discharge column.

## Section 5—Engineering Data

### Sec. 5.1—Discharge Column Pipe

Diameters and weights of standard discharge column pipe sizes are given in Table 5.1.

### Sec. 5.2—Column Friction Loss

The column friction chart (Fig. 5.2) should be used to determine the loss in head due to column friction. This chart has been compiled from data on head losses where the flow is between

the inside diameter of the column pipe and the outside diameter of the shaft enclosing tube.

For open line shafting, the losses shown on Fig. 5.2 should be used by assuming the losses equal to those indicated on the chart for a shaft enclosing tube of a size that would normally enclose the open line shaft in question.

### Sec. 5.3—Discharge Head Loss

The discharge head loss chart (Fig. 5.3) should be used to determine the

#### Explanation of Fig. 5.2.

Diagonals are labeled to show nominal diameters (in inches) of outer pipe column and inner shaft enclosing tube. For the outer pipe columns, the calculations used in constructing the chart were based on inside diameters, which are close to the nominal sizes for pipe up to and including 12 in. (for example, 10 in. = 10.2-in. ID); in sizes 14 in. and larger, the diameters shown are equivalent to the outside diameter of pipe  $\frac{1}{8}$  in. in wall thickness (for example, 16 in. = 15 $\frac{1}{2}$ -in. ID). For the inner columns (shaft enclosing tubes), the calculations were based on the outside diameters of standard or extra-heavy pipe. Thus, "8 x 2" on the chart is actually 8.071 x 2 $\frac{1}{2}$ , and "16 x 3" is 15 $\frac{1}{2}$  x 3 $\frac{1}{2}$ . (Chart reprinted by permission of Hydraulic Institute, Inc.)

TABLE 5.1  
Standard Specifications for Discharge  
Column Pipe

Nominal Size (ID) in.	OD in.	Weight per Foot (Plain Ends) lb
2 $\frac{1}{2}$	2.875	5.79
3	3.500	7.58
3 $\frac{1}{2}$	4.000	9.11
4	4.500	10.79
4 $\frac{1}{2}$	5.000	12.54
5	5.563	14.62
6	6.625	18.97
7	7.625	22.26
8	8.625	24.70
9	9.625	28.33
10	10.750	31.20
12	12.750	43.77
14*	14.000	54.57
16*	16.000	62.58

\* OD.

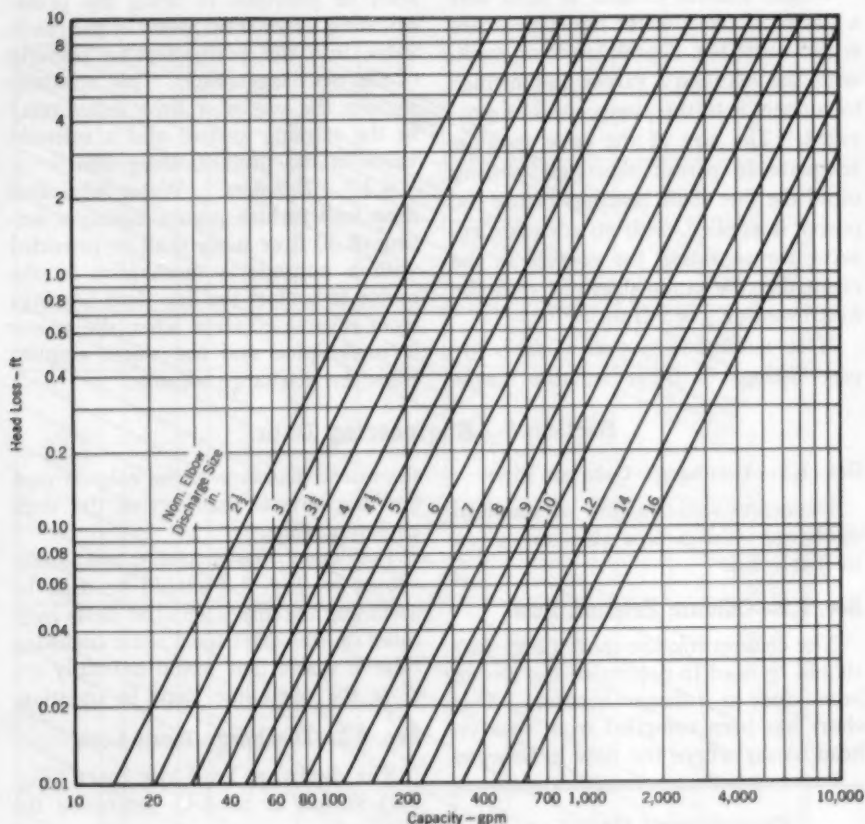


Fig. 5.3. Head Loss in Discharge Heads

hydraulic losses in the discharge head. Losses in discharge heads vary with the size of the head, the design of the head, and the size of tubing or shaft, column, and discharge pipe used. Figure 5.3 represents estimated average losses. Where extreme accuracy is imperative, actual loss measurements in the discharge head to be used—with the correct tubing or shaft, column, and discharge pipe—should be specified on the bid request by the purchaser.

#### Sec. 5.4—Mechanical Friction

The mechanical-friction chart (Fig. 5.4) should be used to determine the

added horsepower due to mechanical friction in rotating the line shaft. The chart was compiled from test data submitted by representative turbine pump manufacturers. Variations in designs

#### Explanation of Fig. 5.4

The chart shows values for enclosed shaft with oil or water lubrication and drip feed, or for open shaft with water lubrication. For enclosed shaft with flooded tube, read two times the value of friction shown on the chart. (Chart reprinted by permission of Hydraulic Institute, Inc.)

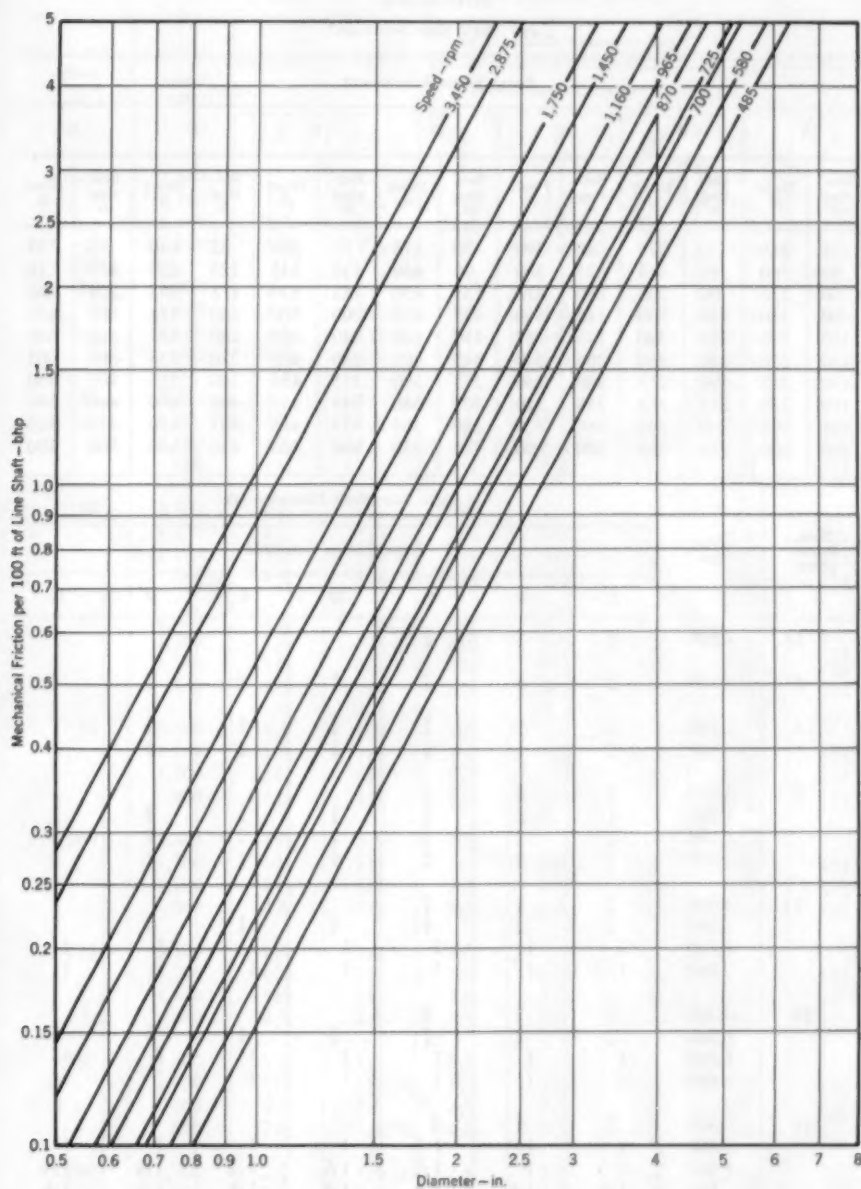


Fig. 5.4. Mechanical Friction in Line Shafts (See Note on Facing Page)

TABLE 5.5  
Line Shaft Size Selection\*

Pump Thrust Conditions†													
A		B		C		D		E		F		G	
Setting ft	Head ft	Setting ft	Head ft	Setting ft	Head ft	Setting ft	Head ft	Setting ft	Head ft	Setting ft	Head ft	Setting ft	Head ft
25	245	30	320	40	390	50	475	55	555	65	640	75	735
50	240	65	315	75	380	90	460	110	535	125	620	140	710
70	235	90	305	110	370	135	450	155	520	175	595	205	680
90	230	120	300	145	360	175	435	200	500	230	575	260	655
110	225	145	290	175	350	210	420	240	485	280	555	315	630
130	220	170	280	205	340	245	405	280	470	320	535	360	605
150	215	190	275	230	330	275	390	315	450	360	515	405	580
170	210	215	265	255	320	305	380	345	435	395	490	440	550
185	205	230	260	280	310	330	365	375	415	425	470	475	525
200	200	250	250	300	300	350	350	400	400	450	450	500	500

Max. Horse- power	Speed rpm	Min. Line Shaft Diameter—in.							
		Pump Thrust Condition							
		A	B	C	D	E	F	G	
1½	3,500	¾	¾	¾					
2	1,760	¾	¾	¾	¾	¾	¾	¾	
3	1,160	¾	¾	¾	¾	¾	¾	¾	
	860	¾	¾	¾	¾	¾	¾	¾	
5	3,500	¾	¾	¾					
	1,760	¾	¾	¾	¾	¾	¾	¾	
	1,160	¾	¾	¾	¾	¾	¾	¾	
	860	¾	¾	¾	¾	¾	¾	¾	
7½	3,500	¾	¾	¾					
	1,760	¾	¾	¾	¾	¾	¾	¾	
	1,160	1	1	1	1	1	1	1	
	860	1	1	1	1	1	1	1	
10	3,500	¾	¾	¾					
	1,760	¾	¾	¾	¾	¾	¾	¾	
	1,160	1	1	1	1	1	1	1	
	860	1	1	1	1	1	1	1	
15	3,500	¾	¾	¾					
	1,760	1	1	1	1	1	1	1	
	1,160	1	1	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	
	860	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	
20	3,500	¾	¾	¾					
	1,760	1	1	1	1	1	1	1	
	1,160	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	
	860	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	

\* For SAE 1020 carbon steel.

† Maximum total pumping head for settings shown.

TABLE 5.5—Line Shaft Size Selection (contd.)\*

Max. Horse- power	Speed rpm	Min. Line Shaft Diameter—in.						
		Pump Thrust Condition						
		A	B	C	D	E	F	G
25	3,500	1	1	1				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	1,160	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	860	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
30	3,500	1	1	1				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	1,160	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	860	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
40	3,500	1	1	1				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	1,160	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	860	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
50	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	1,160	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	860	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
60	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$
	1,160	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	860	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
75	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	1,160	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	860	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
100	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	1,160	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	860	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
125	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	1,160	$1\frac{1}{8}$	$1\frac{1}{8}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
	860	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
150	3,500	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$				
	1,760	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
	1,160	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
	860	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
200	1,760	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
	1,160	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$
	860	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$

\* For SAE 1020 carbon steel.

TABLE 5.5—Line Shaft Size Selection (contd.)\*

Max. Horse- power	Speed rpm	Min. Line Shaft Diameter—in.						
		Pump Thrust Condition						
		A	B	C	D	E	F	G
250	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
300	1,760	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
350	1,760	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
400	1,760	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$	2 $\frac{7}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
450	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
500	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	1,160	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	860	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
600	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
	1,160	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
	860	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$
700	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	2 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
	1,160	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$		
800	1,760	2 $\frac{1}{16}$	2 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
	1,160	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$		
900	1,760	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$
1,000	1,760	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$	3 $\frac{1}{16}$

\* For SAE 1020 carbon steel.

used by individual manufacturers may affect the figures slightly.

### Sec. 5.5—Line Shaft Selection

Line shaft selection should be made in accordance with the following procedure, using Table 5.5.

5.5.1. Table 5.5 does not limit the maximum rotative speed of shafts, the

maximum setting of shafts, or the bearing spacing used with the shafting.

5.5.2. Table 5.5 defines the maximum recommended horsepower for a given size of shaft, taking into account the setting of the pump, the effect of the hydraulic thrust of the pumping equipment, and the weight of the line shafting. The ratings listed are based

on the use of SAE 1020 cold-finished steel. The maximum stresses used comply with those listed.

5.5.3. When an electric-motor driver is used, the horsepower applied to the shaft may exceed that listed by 15 per cent.

5.5.4. For conditions not indicated

in Table 5.5, or for any material other than SAE 1020 steel, the shaft size shall be calculated in the manner described in Sec. 4.2.3 or 4.3.3 ("Pump Shaft"). A maximum of 7,000-psi combined shear stress ( $P_t$ ) shall be used for line shaft calculations when SAE 1020 steel is used.

## Section 6—Factory Inspection and Tests

### Sec. 6.1—Performance Tests

6.1.1. The standard procedure for determining the performance of a vertical turbine pump by making a factory laboratory test of the bowl assembly and then calculating the anticipated field performance is described below. A performance test will be made only when specified in the purchaser's inquiry and order. The inquiry and order shall specify which of the following are required:

- a. Standard running test
- b. Witnessed running test
- c. Shop inspection
- d. Hydrostatic test of discharge head
- e. Hydrostatic test of bowl assembly

If other tests are required, the purchaser shall describe them in detail.

6.1.2. The manufacturer shall notify the purchaser not less than 10 days prior to the date the pump or pumps will be ready for inspection or witness test.

### Sec. 6.2—Standard Running Test

6.2.1. The pump bowl assembly will be operated from zero capacity to the maximum capacity shown on the performance curve submitted with the manufacturer's bid. Readings shall be taken at a minimum of five capacity points, including one point within  $\pm 2$  per cent of the design capacity specified on the request for bid.

The pump shall be operated at a speed within  $\pm 5$  per cent of the de-

sign speed. This does not apply to model or slow-speed tests described in Sec. 6.9.

6.2.2. At the conclusion of the test, three copies of the test data sheet and the anticipated field performance curve shall be supplied to the purchaser.

### Sec. 6.3—Typical Laboratory Test Arrangement

Figure 6.3 indicates a typical laboratory arrangement for the testing of a vertical turbine pump. A test laboratory will normally be constructed to provide favorable suction conditions for pump performance. If the purchaser plans to use the pump under questionable well or sump conditions and wishes the pump to be tested under these exact conditions, complete information should be included in the request for bid. If there is nothing stated in the bid with relation to required well or sump conditions, it is assumed that standard laboratory arrangements will be used.

### Sec. 6.4—Capacity Measurement

The capacity of the pump shall be measured by means of a standard venturi tube, nozzle, orifice plate, or pitot tube traverse. The pump manufacturer shall supply evidence that the capacity-measuring device used has been properly calibrated, that it is in good condition, and that the pressure taps and piping are proper for the instrument being used and are essentially

the same as during the calibration. Instruments which have not been calibrated should be geometrically similar to properly calibrated models.

A description of the application of fluid meters is contained in the ASME publication, "Fluid Meters—Their Theory and Application." A detailed description of the various meters and their application is given in Chapter B-2 of that publication, the physical constants and meter coefficients are in-

with the recommendations by the manufacturer of the fluid-measuring device.

Fluid manometers should be used for measuring the pressure differential across the meter.

### Sec. 6.5—Head Measurement

All pump bowl assembly tests shall be made in open sumps, unless otherwise stated in the request for bid.

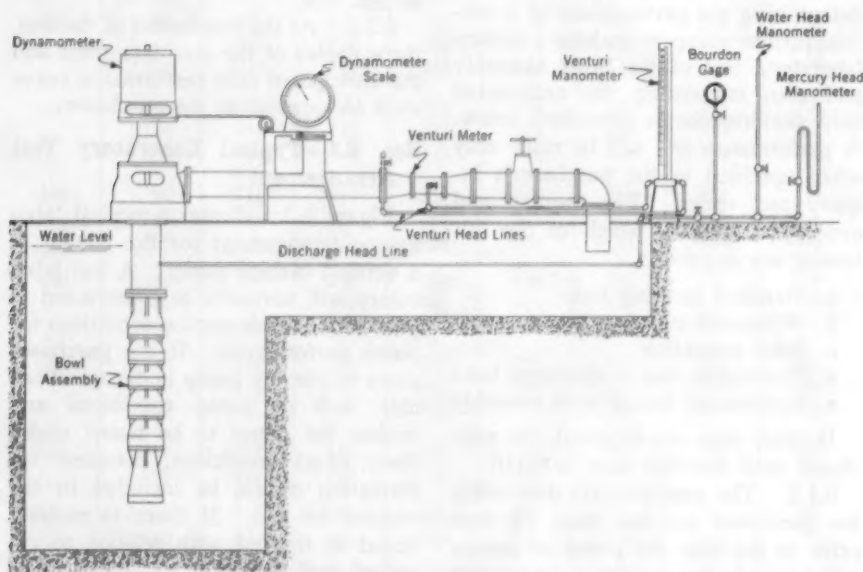


Fig. 6.3. Typical Laboratory Test Arrangement

dicated in Section C, and the discharge coefficient tolerances of the various meters are indicated in Chapter C-7.

The surface conditions, size, and length of the pipe preceding the fluid-measuring device are as important as the calibration of the device itself. Thus, piping should be in close conformity with that used when the instrument was calibrated or in accordance

The pressure tap for head measurement shall be located in the discharge column not less than 2 ft above the pump bowl assembly. The pressure tap shall be at right angles to the pipe, free from burrs, and flush with the surface of the column pipe. The openings shall be of a diameter from  $\frac{1}{8}$  to  $\frac{1}{4}$  in. and of a length not less than twice the diameter.

As an alternate method, the pressure tap for head measurement can also be located not less than ten diameters downstream from the discharge elbow of the test pump. (The elbow to be furnished with the pump shall be used.) When the pump head is measured at this point, no deduction for elbow loss need be made in anticipating field performance.

For head measurements of 36 ft or less, only fluid manometers shall be used. For head measurements in excess of 36 ft, calibrated Bourdon or other gages with equivalent accuracy and reliability can be used. All gages shall be calibrated before and after each series of tests.

#### **Sec. 6.6—Velocity Head**

The average velocity in the pump column used to determine the velocity head shall be calculated from dimensions obtained by actual measurement of the pipe and shaft or enclosing-tube diameter at the point of pressure measurement.

If the pressure measurement is made downstream from the discharge elbow, the velocity head shall be obtained from actual measurement of the inside diameters of the discharge pipe at the point where the pressure tap is located.

#### **Sec. 6.7—Horsepower Input to Pump**

The power input to the pump shall be determined by means of a vertical dynamometer or a calibrated electric motor.

The torque of the dynamometer shall be measured by means of a calibrated springless scale, calibrated strain gage, or other device of equivalent accuracy.

Squirrel-cage induction motors (when operated at greater than half the name plate rating), direct current

motors, synchronous motors, or wound-rotor induction motors with short-circuited secondary resistance may be employed for the determination of shaft input, provided the efficiencies or losses have been ascertained by an AIEE test or its equivalent.

Where the specifications call for an overall efficiency guarantee, the actual job motor can be used without calibration and the overall bowl assembly efficiency calculated directly.

Calibrated laboratory type electric meters and transformers shall be used to measure the power input to all motors.

#### **Sec. 6.8—Measurement of Speed**

The rotating speed of the pump shall be obtained by a hand counter or a stroboscope counting slip. It should be noted that an accurate speed reading is important in determining power input when a dynamometer is used. Accuracy is less important when a calibrated motor is used.

#### **Sec. 6.9—Large-Pump Tests**

6.9.1. On all pump bowl assemblies where the horsepower is not in excess of 200 and the bowl diameter is not in excess of 20 in., the actual pump shall be tested in the manufacturer's laboratory.

6.9.2. If the horsepower exceeds 200, it shall be permissible for the manufacturer to test only the number of stages of the unit which come within this power requirement. If a test is made on a limited number of stages, no increase in efficiency shall be permitted for an increased number of stages when predicting the final performance of the complete bowl assembly. The head and horsepower shall be increased in direct proportion to the number of stages in the final assembly, compared

with the number of stages used in the laboratory test.

6.9.3. When the size of the bowls exceeds 20-in. OD, a laboratory test on a model pump, homologous with the actual unit, may be used as a basis for the determination of the performance of the actual unit. (In general, when contract guarantees are to be based on model tests, the contract should specify model performance rather than inferred actual-unit performance. In the absence of this provision, allowance for the scale effect, if any, shall be agreed upon in writing by the representatives of both parties prior to the tests.)

The model pump shall be run at a speed sufficient to develop a head per stage at least equal to that of the actual unit, so that the velocities will equal or exceed those of the actual unit; or the manufacturer must submit evidence that a single-stage model does not cavitate under specified field suction conditions when operated at a speed such that the velocities will equal or exceed those of the actual unit.

6.9.4. On bowl assemblies which have an OD exceeding 20 in. or which require more than 200 hp, it will be permissible to test the actual bowl assembly at a speed slower than that at which the pump will run in the field rather than make a model test. No efficiency increase will be allowed when the performance in the slow-speed test is translated into that at full speed. The manufacturer must submit evidence that a single-stage bowl assembly or a single-stage model does not cavitate under specified field suction conditions when operated at a speed such that the velocities will equal or exceed those of the actual unit.

6.9.5. All large bowl assembly full-speed tests or model tests must be conducted with the identical submergence

that will exist in the field, as shown on the request for bids.

### Sec. 6.10—Hydrostatic Tests

6.10.1. A standard hydrostatic test on the pump bowl assembly shall be made at  $1\frac{1}{2}$  times the shutoff head developed by the pump bowl assembly, or at twice the rated head, whichever is greater.

6.10.2. A standard hydrostatic test on the discharge head shall be made at the pressure defined in Sec. 6.10.1, less the pump setting specified on the order.

### Sec. 6.11—Recording and Computation of Test Results

6.11.1. All instrument test readings, as well as corrected readings, shall be recorded on the test sheet. Complete data concerning the pump, driver, and instrument identification shall also be recorded.

6.11.2. All test results shall be translated into performance at the anticipated speed of the driver at the design point, using the following formulas:

$$Q = Q_t \frac{N}{N_t}$$

$$H = H_t \left( \frac{N}{N_t} \right)^2$$

$$\text{bhp} = \text{bhp}_t \left( \frac{N}{N_t} \right)^3$$

in which  $Q$  is capacity (gpm),  $H$  is head (ft of water), bhp is brake horsepower,  $N$  is anticipated operating speed (rpm), and subscript " $t$ " indicates test values.

6.11.3. The bowl assembly input horsepower, when measured by a vertical dynamometer, is found from the expression  $KFN_t$ , in which  $K$ , the

dynamometer constant, equals  $\frac{2\pi L}{33,000}$ ,  
 $L$  is the length (ft) of the lever arm,  
 $F$  is the net force (lb) at the end of  
 the lever arm, and  $N$  is the speed  
 (rpm) of the driver when the test  
 reading is taken.

6.11.4. The motor power input, in  
 horsepower, is the corrected kilowatt  
 input to motor divided by 0.746.

6.11.5. The bowl assembly input  
 horsepower to a pump driven by an  
 electric motor is:

$$\frac{\text{kw}}{0.746} \eta_m$$

kw being the corrected kilowatt input  
 to motor and  $\eta_m$  the motor efficiency  
 from the calibration curve.

6.11.6. The pump bowl assembly  
 efficiency ( $\eta_l$ ) is:

$$\frac{Qh_l}{3,960 \times (\text{bhp})}$$

in which  $Q$  is the measured capacity  
 (gpm);  $h_l$  is the bowl assembly head  
 (ft), including velocity head; and bhp  
 is the brake horsepower to the pump  
 bowl assembly, measured by dyna-  
 mometer or calibrated motor.

6.11.7. The pump total head ( $H$ ),  
 in feet, is found by:

$$H = h_l - h_e - h_o$$

in which  $h_l$  is the bowl assembly head  
 (ft), from test;  $h_o$  is the column loss

(ft), obtained from Fig. 5.2 and based  
 on complete pump setting; and  $h_e$  is  
 the discharge head loss (ft), from Fig.  
 5.3 or actual test.

6.11.8. The pump input horsepower  
 equals the bowl assembly input horse-  
 power plus the line shaft loss in horse-  
 power. The bowl assembly input  
 horsepower is calculated from test, as  
 in Sec. 6.11.3 or 6.11.5. The line shaft  
 loss is obtained from Fig. 5.3 and based  
 on complete pump setting.

6.11.9. The pump efficiency ( $\eta_p$ )  
 is found by:

$$\eta_p = \frac{QH}{3,960 \times \text{pump input hp}}$$

in which the pump total head ( $H$ ) is  
 obtained from Sec. 6.11.7 and the  
 power input from Sec. 6.11.8.

6.11.10. The overall efficiency ( $\eta$ )  
 is the pump efficiency ( $\eta_p$ ) multiplied  
 by the motor efficiency ( $\eta_m$ ).

6.11.11. The complete pump total  
 head, efficiency, and pump input horse-  
 power should be plotted as ordinates  
 on the same sheet against the capacity  
 as abscissa to show the anticipated field  
 performance of the complete pumps.

## Sec. 6.12—Other Tests

For more complete tests, or for tests  
 involving fluids other than water, refer  
 to the ASME "Power Test Code for  
 Centrifugal and Rotary Pumps" as  
 applicable.

## Reprints Available

Reprints of the following articles, published in the JOURNAL during the preceding year, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 521 Fifth Avenue, New York 17, N.Y. **Prepayment required on orders under \$2.** (Note: This list does not include specifications and similar documents kept permanently in stock.)

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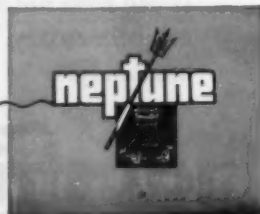
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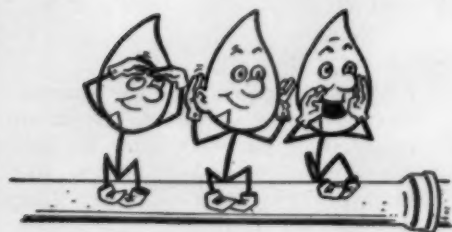
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## Percolation and Runoff

Chi high was an almost unbelievable 2,587! That was more than 500—in fact, more than 25 per cent—above the previous registration record, set only last year at Seattle. As AWWA executive Reeves Newsom put it: “Almost everybody anybody can think of is here.”

And, as might be expected, “almost everybody” contributed to making AWWA’s 75th annual conference the very best ever in just about every way. With more men present than there had ever been total registrants before, sessions were practically all S.R.O., and the 100 speakers on the technical program made even standing worth while. Meanwhile, to give the show more rings than Ringling Brothers, there were 167 booths of exhibits, 30 committee meetings, 21 inspection trips, and no end of luncheons and other official activities always on tap. No one ever wanted for things to do—or, certainly, for people with whom to do them—or, in the world’s largest hotel, for a convenient corner or ballroom.

In the evenings, the men—from their work—and the ladies—from their card parties, lunches, and teas—got together for a full round of social events. Then, too, the S.R.O. signs were in order, beginning with a sellout Sunday buffet and continuing through the Thursday banquet for 1,100.

Monday night’s salute to the AWWA Men of the Year featured Honorary Members Lou Ayres, Linn Enslow,

and Herbert Foote; Diven Medalist A. P. Black; Goodell Prizewinner Paul Haney; 25 Fuller Awardees; and the winners of five new AWWA honors: Erwin Potthoff, John Murdoch, Paul Haney (again), and Herb Hudson, respectively recipients of the Distribution, Management, Purification, and Resources Division Awards; and Paul Kuhn, graduate student at Northwestern Technological Institute, first winner of the Harry E. Jordan Scholarship Award. As has become the custom, the President’s Reception topped off this evening of tradition and glory.

Tradition of another kind was loosed on Tuesday, when the Diamond Jim Carnival was patronized by a couple thousand mustached or bustling gamblers, who vied not only for bogus bucks that bought prizes but for costume awards as well. (A list of winners and their tintypes will appear in a later issue, together with a report on the golfers who took advantage of fair weather and fast greens to participate in this year’s WSWMA Open.)

For a change of pace, Wednesday offered a quiet evening at the movies, but Thursday shifted back into high again, with the biggest crowd ever, at the Annual Banquet & Ball. Feature of that program was Frank Amshary’s inaugural speech, but there were other high spots, too: One was the presentation of section awards—the Hill Cup

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to the Pacific-Northwest Section, the Henshaw Cup to the Alabama-Mississippi Section, and the Old Oaken Bucket, for the sixteenth consecutive year, to the California Section; another, the commissioning of Harry Jordan as an Admiral in the Nebraska Navy in a semisolemn ceremony supervised by Admiral John Cramer, duly designated representative of Governor Anderson of that state and fleet.\* Not to be forgotten either was the able emceeing of Ed Alt, who, as Chairman of the Convention Management Committee, had been doing just that for his crew of more than 200 members of the local section, to whom credit for both the quantitative and qualitative successes of the meeting must go. Introduced as heads of this host of hosts were Ed's first lieutenants, Jeff Abplanalp and Dewey Johnson; Mrs. Warren Wolfe, who handled the ladies' program, and Tom Quigley and Lou

Frazza, who represented the manufacturers on Ed's committee. Given top billing, too, for their work as committee chiefs were Jim Jardine, Roy Beckman, Scranton Gillette, Tom Storms, Hy Gerstein, Mike Foley, Warren Wolfe, Clarence Klassen, and the Missuses Cy Bird, John Barksdale, Ed Alt, and Harry Schlenz, all of whom must now be ready for a vacation. Meanwhile, the more than ever before danced in AWWA's 75th year.

Missing and missed throughout the week—his week—was President Dale Maffitt, ordered by his doctor to remain at home to recuperate from an illness that has plagued him for the past several months. With 2,075 of Dale's males on hand to represent him, getting his work done was no problem at all, but Dale's work wasn't why he was missed. To make it up to him, all of the Chi high—and then some—have promised to be on hand to greet Dale next May in St. Louis, to help him help AWWA celebrate its 75th birthday.

\* A Kentucky Colonel already, Harry claims to covet nothing now but an appointment to the Confederate Air Force.

### Chicago Registration by Days

DAY	MEN	LADIES	TOTAL
Sunday, Jun. 12.....	1,085	309	1,394
Monday, Jun. 13.....	674	162	836
Tuesday, Jun. 14.....	170	35	205
Wednesday, Jun. 15.....	100	6	106
Thursday, Jun. 16.....	46	-	46
<b>TOTALS</b> .....	<b>2,075</b>	<b>512</b>	<b>2,587</b>

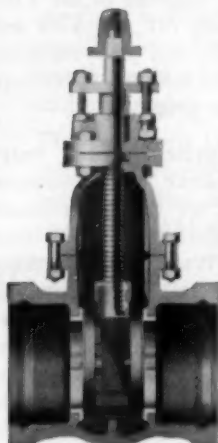
### Comparative Registration Totals—1946-1955

YEAR	PLACE	MEN	LADIES	TOTAL
1955	Chicago	2,075	512	2,587
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967
1948	Atlantic City	1,348	356	1,704
1947	San Francisco	1,115	431	1,546
1946	St. Louis	1,303	214	1,517

(Continued on page 38 P&amp;R)



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(Continued from page 36 P&R)

**Water Works Week**, an idea promoted rather casually in connection with AWWA's last few annual conferences, has recently been receiving moral support from the grass roots. Latest of the rooters has been M. H. Phillips, Paragould, Ark., water superintendent, who, having observed the local success of Baseball Week and Boy Scout Week, felt that "a week recognizing the water works profession and the invaluable service it renders" would be a natural extension of the Association's present public relations efforts. On the other hand, with more than a hundred weeks and almost that many months already assigned to every year, it may well be more distinctive not to have a week—particularly in the interest of keeping every day "Water Works Day."

Whether it is called that or not, however, the week of AWWA's annual conference is almost bound to be "Water Works Week" for some. Last year, for instance, Seattle's mayor proclaimed it so, and this year it could scarcely be anything else, following, as it did, National Tavern Month. A primary drawback to conference week, of course, is the fact that practically every water superintendent ought then to be away from home and, thus, unable to participate in the local celebration. But, then, Water Works Week might actually help him get the funds to go.

There ought to be a Week?

**H. F. O'Brien**, president of A. P. Smith Mfg. Co., East Orange, N.J., and an AWWA director representing W&SWMA (1952-55), was a member of the United States employer delegation at the 38th session of the UN's International Labor Organization conference held at Geneva in June.

**Omar C. Hopkins**, US Public Health Service sanitary engineer director, has been transferred from his post of regional engineer at the San Francisco office to the Div of International Health, for assignment to the US Operations Mission to New Delhi, India. As public health engineering advisor to the Indian Ministry of Health and chief engineer of the Public Health Mission, Mr. Hopkins will recommend policies and procedures for the development of national water supply and sanitation programs.

**The "Tap Sprite,"** whose entry upon the water scene was announced just recently, is, we think, no faucet fairy at all, no liquid leprechaun come to assist Willing Water, but something odiously commercial: an activated-carbon filter marketed by R. T. Collier Corp. of Los Angeles for use on the kitchen faucet "to remove the chlorine taste from water." The effectiveness of the device, unless several inches of carbon depth are provided, and its durability, unless some form of insulation between the carbon and the perforated aluminum sheets on which it rests is provided, may well be open to considerable question. It is not these factual matters, though, which concern us, but the very idea of the gadget itself. After all, wiping one's silverware on a napkin is hardly the best way to clean it. And if, as usually is true, the wiping isn't really necessary, how gratuitous the insult! "Tap Spite" sounds more like him—with a heart as black as coal!

**Richard Hazen**, partner in the consulting engineer firm of Hazen & Sawyer, New York, has been elected president of the Metropolitan Section of the American Society of Civil Engineers.

(Continued on page 40 P&R)

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The Northern Gravel Company is equipped to give you prompt shipment whether it be one bag or many carloads, exact to specification. Filter sand can be furnished with any effective size between .35 MM and 1.20 MM.

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Northern Gravel has no equal in facilities and our reserves of both sand and gravel are inexhaustible. Northern Gravel Company has been in business over 40 years. We guarantee uniformity of products and our records enable us to duplicate your requirements on short notice. Our location is central and we have commodity rates in every direction.

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(Continued from page 38 P&R)

**Thump the experts** seems to be the current trend in the fluoridation fracas—and fracas is definitely what fluoridation has come to mean, now that the thumpers are managing to rally the opposition almost everywhere the program is proposed, or even in effect. Newest standard bearer for the anti-fluoridationists is the *National Fluoridation News*, a four-page almost monthly newspaper which affords "Unity—Information—Service," apparently by making sure to see no good, hear no good, and say no good about its subject. Fluoridation, if we read the *News* correctly, is a deadly, ineffective, unproved, uneconomical, undemocratic method of combating caries—a method that is actually opposed by those dentists and doctors who know anything

about it and promoted by the Public Health Service for political, if not more sinister, reasons. The scientists who support fluoridation are, presumably, at best, dupes and, at worst, profiteers who have an interest in the Aluminum Co. of America or in some research project supported by the Public Health Service.

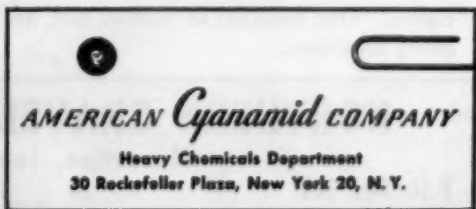
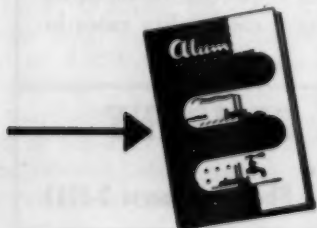
The thumped, meanwhile, have been making the most of celebrating the tenth anniversaries of fluoridation at both Grand Rapids, Mich., and Newburgh, N.Y., where the results are responsibly reported to have confirmed both the safety and effectiveness of the procedure. Rather reassuring, too, to the proponents has been the lack of any semblance of calamity in the more than 1,000 communities in which more

(Continued on page 42 P&R)

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The Protectop Hydrant Standpipe and Valve Stem are equipped with Special Couplings located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

All Smith Hydrants are equipped with Compression Type Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

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38



# THE A.P. SMITH MFG. CO.

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(Continued from page 40 P&R)

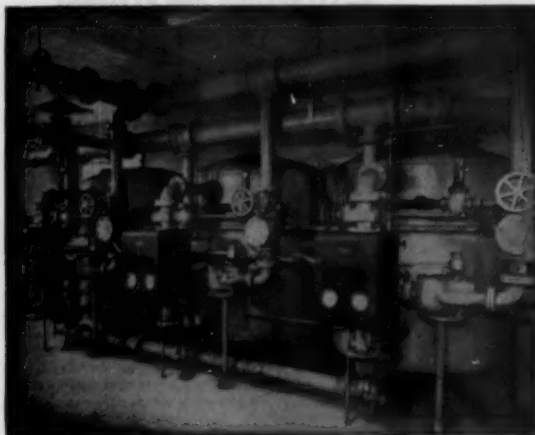
than 20,000,000 people are now drinking fluoridated water. And if the authorities of every new community that considers the program still insist on proving to themselves the wisdom of fluoridation, who can blame them when they are the ones almost certain to be called to task for "poisoning" their constituents? Portland, Ore., authorities are in the process of reviewing such proof now, aided in their task by an objective two-year study of the evidence contributed by a committee of the City Club of Portland. And in New York, Mayor Wagner is calling on his Board of Health for a third study of "all the facts" to make his assurance triply sure. Wherever the subject has come up, as a matter of fact, there has been a struggle of light against fright—of education against

agitation—which, more often than not, has created enough fuss to obscure the merits of the basic proposition.

Happy on the sidelines, thumping only their own tub to give assurance of their readiness, willingness, and ability to serve water either way, have been the utilities which have followed AWWA's policy of sticking strictly to water business. A number of others, who have been unable or unwilling to remain noncombatants, have ranged themselves from one extreme to the other, where, regardless of side, they have found themselves opposing a considerable number of their customers. In that, at least, thumping themth wrong.

**Tub thumpers, too,** in the real drummer sense though, have been two

(Continued on page 44 P&R)



## WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

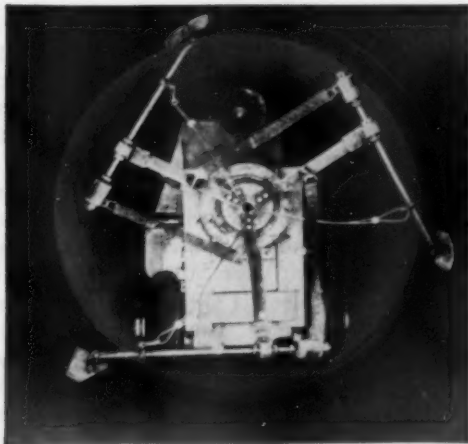
If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

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H & T  
SERVICE

# HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY



## CENTRILINE goes to CUBA

The Centriline process has been selected by Municipio de la Habana to play an integral part in the expansion of this city's water supply system. Over 114,000 feet of new welded steel pipe, ranging in diameters from 30" to 78", will be cement-mortar lined in the near future.

In this process, the novel machine illustrated above is drawn through the pipe while cement-mortar is centrifugally sprayed on the pipe walls and troweled smooth by the

rotating arms. Mortar thickness is controlled by the speed of the entire machine. Because the pipes remain in place throughout the process, traffic interruption is cut to a minimum; time and money are saved.

Whether you're expanding or rejuvenating your water system, follow the lead of progressive city officials and engineers around the world. Call on Centriline to add years of new life to your water supply lines.

*Supervising engineer on the project is Francisco Pividal, C. E.; Chief Engineer is Adrian Macia, C. E.; General Contractor: Comp. Constructora M. A. Gonzales del Valle, S. A.; Pipe Contractor & Manufacturer: Tuberia de Concreto Universal, S. A.*

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*A subsidiary of the Raymond Concrete Pipe Company*

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Branch Offices in Principal  
Cities of the United States  
and Latin America

• CEMENT-MORTAR LINING OF PIPES IN PLACE •

(Continued from page 42 P&amp;R)

new entrants into the fluoridation field:

● FluoridDental of Los Angeles has developed a home fluoridation unit, which, attached to any household faucet, is supposed to dispense 1 ppm F—"or a little less" into the water drawn through it. The fluoride ion is derived from a porous cartridge loaded with magnesium fluoride and set in a dispensing well in which the fluoride dissolves to be ready for mixing with the tap water as it is drawn. How accurate (or effective) such automatically controlled dosage will be is almost obvious from the fact that the safest of the safety features of the device is the relative insolubility of the magnesium fluoride itself. Not on the market yet, the unit has been tentatively priced at about \$5, and the cartridges, good for approximately 4 months of normal household use, at \$1 each—

somewhat higher than the 10¢ per person per year of public water supply fluoridation even though only the water actually consumed is treated. Even so, where anti-fluoridation is strong or where public water supply is non-existent, some believers in fluoridation may find not quite half the loaf at a good bit more than twice the price preferable to nothing at all and certainly safer than homebrewing their fluoridose as was sponsored recently by the Borough of Freehold, N.J., and promptly discontinued at the behest of the state health department.

● Procter & Gamble, which recently heralded the end of dental decay with its anti-enzymatic Gleem, has now gone itself one better with Crest, a toothpaste containing tin fluoride (fluoristan, in commercialese), "the world's most

(Continued on page 46 P&amp;R)

### WHEELER FILTER BOTTOMS

... give these outstanding plants—corrosion free construction • uniform flow distribution • low head loss.

CLEVELAND, OHIO (Havens & Emerson, Engrs.)

NASHVILLE, TENN. (The Chester Engineers)

MIAMI, FLA. (Day & Zimmerman, Inc., Engrs.)

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For details on monolithic and pre-cast Wheeler Bottoms, write Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.



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CONTROLS



No matter how farsighted today's plans may be...  
cities will grow old...  
in time



Famous "4 Corners," 1890—Courtesy of Rochester, N.Y. Chamber of Commerce

Your best insurance against obsolescence of your water system...  
specify **EDDY Valves and Hydrants** *throughout*

No matter how far into the future your city planning is projected, Eddy's record testifies that Eddy Valves and Hydrants are your best long term investment. Eddy Valve Company's more than 100 years of dependable operation means that, today, you can get replacement parts for any Eddy Valve or Hydrant ever installed. And our ability to continue to do so is your assurance against future obsolescence of your valves and hydrants.

**EDDY Bronze-Mounted  
HYDRANTS**

open smoothly with the pressure and close without water hammer. One man can easily remove all operating mechanism for inspection and repair. Stem held in place below hydrant valve means that there is no water loss due to a bent stem.

**EDDY Bronze-Mounted  
GATE VALVES**

offer simplicity of design, trouble-free operation and enduring service. Each is truly a finished product of workmanship. These factors, added to personal experience, tell why progressive water works men have relied on Eddy for generations.



Eddy Hydrants and Valves are available with hub, flange or mechanical joint connections to fit any existing or planned installation.

**EDDY**

VALVE COMPANY

WATERFORD, NEW YORK



(Continued from page 44 P&amp;R)

effective weapon against tooth decay." In research since 1945, when water fluoridation was introduced, Crest is reported to have behind it more than 3 years of clinical testing on 1,500 children and 400 adults. Conducted by Dr. Joseph C. Muhler of Indiana University, these tests have shown a 51 per cent reduction in tooth decay in children and—how much more significant!—a 50 per cent reduction in adults. In process now of being patented by Indiana University, Crest has already been approved for sale by the Food & Drug Administration "with the limitation that children under 6 years old should not use it." In this type of fluoride treatment, of course, dosage is completely uncontrolled, but application is strictly topical and it is

apparently federal judgment that anyone above the age of six can spit.

Together, these two new fluoriders provide the perfect complement to public water supply fluoridation—one covering the places missed, the other, the people missed. And if we continue to remain missed for just a little longer, it will only be because our toothbrush runneth over—with the plain, the ammoniated, the chlorophyll, and the anti-enzymatic, none of which—having read their guarantees—we would dare omit. Ah, to be toothless and fancy free!

Karl F. Hoefle, who has been water superintendent at Dallas, Tex., since 1946 and aided in the design and construction of Lake Dallas, has resigned and gone into semiretirement. His

(Continued on page 48 P&amp;R)

# MUNICIPAL SUPPLIES

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Invited!*

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# Life begins at forty for steel pipe like this



THIS PICTURE WAS TAKEN IN 1915. Ever since, this 84-inch steel pipe has been an important part of Baltimore, Maryland's water system, distributing water from the Montebello Filtration Plant. It is protected against corrosion by Bitumastic Enamel.

This picture was taken forty years ago, right after this steel pipe had been hand-brushed with Bitumastic® Enamel. Thanks to this protection against corrosion, these mains are *still* an important part of Baltimore's water system. And the end of this pipe's useful service life is nowhere in sight.

A recent inspection bears out this statement. A group of water works engineers

examined the 70-B Enamel Coating and reported it to be in excellent condition.

A 40-year record is good; but nowadays, even better records can be expected. Today Bitumastic Enamel is applied *mechanically* to exterior and interior surfaces of pipelines, thus providing thicker protection, more uniform protection. And Bitumastic Enamels, themselves, are even better products.

Service records like this prove that it pays to use strong steel pipe, protected by Bitumastic Enamel. It's an economical combination for your large-diameter water lines. Write for full information.

## SEWAGE EQUIPMENT PROTECTION!

Koppers also makes Bitumastic® Protective Coatings for all kinds of sewage-plant equipment. Give your expensive equipment the effective protection it deserves. Write for complete data.



MADE ONLY BY KOPPERS  
**BITUMASTIC ENAMELS**

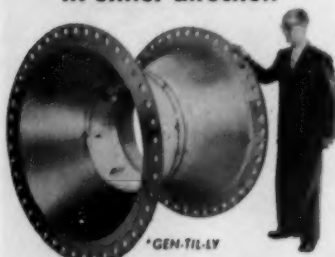
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**LOW INSTALLED COST . . .** Average length is only  $1\frac{1}{2}$  times the pipe diameter, and straight runs entering and following are not required unless installed near throttling valves or regulators.

**ACCURACY . . .** Produces differential from points of equal cross-sectional area . . . furnished with head capacity curves, and guaranteed for exceptional accuracy when used with any standard indicating, recording or integrating meter.

**LOWEST HEAD LOSS . . .** The Flow Tube can be designed to produce a measurable differential with the lowest permanent pressure loss of any type head meter.

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AUTOMATIC VALVES • CONTROL VALVES  
 SAFETY VALVES • FLOW TUBES

(Continued from page 46 P&R)

successor is Henry J. Graeser, assistant water superintendent since 1950. On resigning, Mr. Hoeffle was named a member of the city's long-range water survey committee.

Crane Co. celebrated its 100th birthday this month. The firm had its beginning on Jul. 4, 1855, when Richard Teller Crane opened a one-man, self-built, 14 x 24-ft frame shop in Chicago. The R. T. Crane Brass & Bell Foundry, as the company was then known, first produced brass couplings and copper tips for lightning rods. Today, in fourteen plants located in the United States, Canada, and England, Crane Co. makes thousands of prod-



R. T. Crane



F. F. Elliott

ucts. A basic list includes valves, fittings, fabricated piping and piping accessories, plumbing and heating equipment, and accessory equipment for aircraft. Frank F. Elliott, a veteran of 33 years' service with the organization, is president and chief executive officer, having recently succeeded John L. Holloway, who resigned because of ill health.

W. J. M. Cook has been appointed manager of the Industrial Sales Div., Paterson Engineering Co., Ltd., London. Mr. Cook was formerly chief chemist for Neckar Water Softener Co., Ltd., London.

(Continued on page 52 P&R)

# Triangle Brand Copper Sulphate

## HELPS SOLVE YOUR WATER PROBLEMS

Triangle Brand Copper Sulphate economically controls microscopic organisms in water supply systems. These organisms can be eliminated by treatment of copper sulphate to the surface. Triangle Brand Copper Sulphate is made in large and small crystals for the water treatment field.

Roots and fungus growths in sewage systems are controlled with copper sulphate when added to sewage water without affecting surface trees.

*Booklets covering the subject of control of microscopic organisms and root and fungus control will be sent upon request.*



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# ELIMINATE SERVICE INTERRUPTIONS

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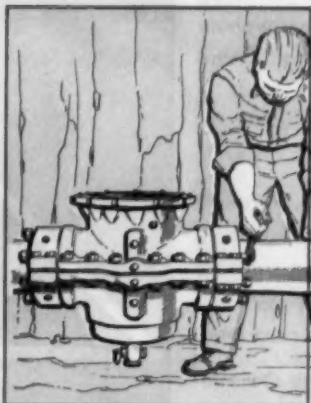
Now you can install control valves without shutting down even a small part of your city's water system. Inconvenience to customers and danger of fire is completely avoided by using Mueller Inserting Valves.

Mueller Inserting Valves may be installed in any existing line under pressure and, once installed, are operated like standard gate valves. In fact, the mechanism of Mueller Inserting Valves is identical to that of Mueller AWWA Gate Valves and repair parts are interchangeable.

Follow this procedure to install . . .



**STEP 1. BOLT SLEEVE TO MAIN.**  
Main is cleaned and sleeve halves are bolted together around main.



**STEP 2. PREPARE SLEEVE.**  
Sleeve is calked and leaded to main in desired position and slide valve is attached.



**STEP 3. MAKE CUT.**  
Section of main inside of sleeve is removed with Mueller "CC" or "C-1" Drilling Machine.



"CC" or "C-1" Drilling Machine



H-810 Basic Inserting Equipment

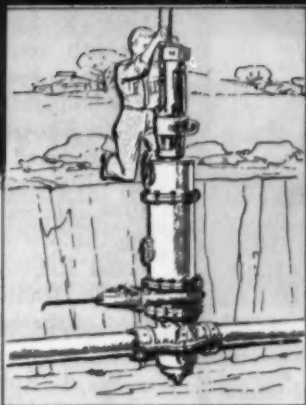


H-800 Inserting Valve

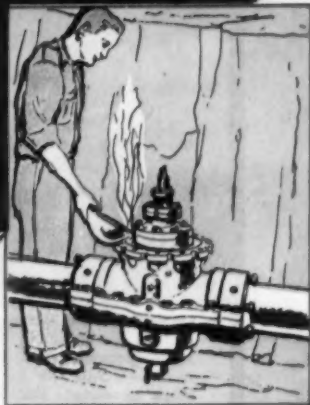
# FIRE HAZARDS!



STEP 4. PREPARE VALVE PLUG.  
Adapter is bolted to slide valve and valve plug is readied for insertion into main.



STEP 5. INSERT VALVE PLUG.  
"C-I" machine is fastened to valve plug to lower plug into place under pressure.



STEP 6. COMPLETE INSTALLATION.  
Packing screws are tightened and lead is poured into top joint to seal valve plug in place.

Control Valves at vital points permit:

- Installation or repair of fire hydrants
- Isolation of small sections
- Extension of mains
- Modification of system . . . without extensive shutdown

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(Continued from page 48 P&R)

**Herbert A. Kroeze**, director of the Div. of Sanitary Engineering, State Board of Health, Jackson, Miss., died late in April at the age of 64. Born at Grand Rapids, Mich., in 1892, he was educated at Jamestown College in North Dakota and at the University of Minnesota, where he obtained a civil engineering degree in 1919. In 1920 he joined the US Public Health Service as an assistant sanitary engineer at Nashville, Tenn., but left the same year to become head of the newly organized Mississippi Div. of Sanitary Engineering. Under Mr. Kroeze's leadership, the division's sanitation program—including water and sewage works supervision, food inspection, and malaria and shellfish control—contributed greatly to the health and longevity of Mississippians.

Mr. Kroeze joined AWWA in 1938 and received the Fuller Award from the Alabama-Mississippi Section in 1949. He was instrumental in organizing the Mississippi Society of Professional Engineers and the Mississippi Public Health Assn., serving as president of the latter in 1938.

**W. A. Roberts**, president of Allis-Chalmers Mfg. Co., Milwaukee, died of a heart attack on Apr. 12 at the age of 57. Starting as a salesman with the firm's tractor division at Wichita, Kan., in 1924, Mr. Roberts rose to the position of executive vice-president in charge of the division in 1947. He became a company director in 1948 and was elected president in 1951. His outside activities included membership on the President's Advisory Committee on the National Highway Program, the National Industrial Conference Board, and the National Safety Council. He was also affiliated with numerous trade and civic groups.



## 48 miles of CONCRETE pipe assure adequate water supply for Savannah River Project

Producing materials for A and H bombs at the Savannah River Plant in South Carolina requires enormous quantities of water. This water, from the Savannah River, is distributed by 48 miles of concrete pipe on the 315 square-mile site.

Extremely difficult engineering problems were encountered because of the high water table in the area. Many lines had to be laid through swamps and under railroads.

Whether the water line you plan is long or short, concrete pipe offers the rugged strength, long life and economy necessary for satisfactory service. Its tight joints and dense structure prevent leakage and infiltration.

Not being subject to damaging internal corrosion, durable concrete pipe maintains constant hydraulic efficiency. It delivers long years of dependable, *low-annual-cost* service.

### CONCRETE PIPE USED IN SAVANNAH RIVER PROJECT

48"	410 ft.
54"	5,250 ft.
60"	28,493 ft.
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72"	23,178 ft.
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84"	100,529 ft.

### PORTLAND CEMENT ASSOCIATION

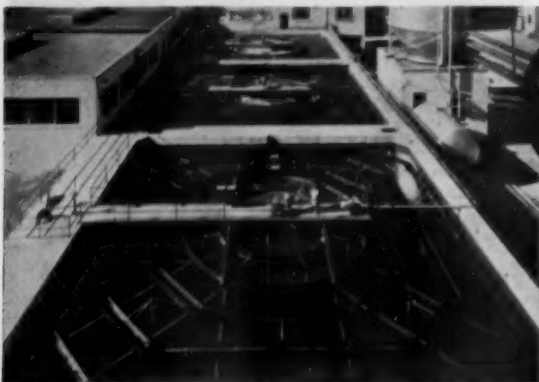
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WALKER PROCESS

# Clariflow

Orlando, Florida Water Treatment Plant includes three Walker Process Clariflows for lime softening as well as algae and color removal. The unit in the foreground, completed in 1954, increases the plant capacity to 24 MGD. The two original Clariflows were installed in 1949. Each unit is 56' square x 17' deep.

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The Clariflow combines flocculation, good fluid mechanics and clarification in a relatively small tank. Mixing, flocculation, stilling and sedimentation are independently operated and controlled. The positive control of flocculation and clarification enables the operator to readily select the most economical method of operation when handling changeable water conditions.

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The Clariflow is applicable wherever there is a municipal or industrial need for water or waste treatment. It can be used in all operations including combined intimate chemical homogenizing, flocculation and clarification in rectangular, square or circular basins. The Clariflow gives excellent results in the treatment of municipal and industrial water for—softening—turbidity removal—color removal—algae removal. Industrially it is universally used in—oil separation and emulsion breaking plants—blast furnace flue dust thickening—paper stock reclamation.

Write for bulletin 6W 46.

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**Key:** In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is pagged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH*—*Bulletin of Hygiene (Great Britain)*; *CA*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *IM*—*Institute of Metals (Great Britain)*; *PHEA*—*Public Health Engineering Abstracts*; *SIW*—*Sewage and Industrial Wastes*; *WPA*—*Water Pollution Abstracts (Great Britain)*.

## BACTERIOLOGY

### Experiments on Biological Destruction of Phenols Under Aeration by *Nocardia*.

G. BRINGMANN. *Gesundh.-Ing. (Ger.)*, 75: 252 ('54). *N. rubra* was acclimatized by addns. of mineralized 100-ppm phenol solns. to destroy 500 ppm in 24 hr, or 1,600 ppm in 48 hr when 1 l air/min/l of soln. was used. Concns. above 2,000 ppm retarded growth. Activity can only be maintained by continuous loadings which may vary by  $\pm 200$ –300 ppm. Variations by  $\pm 400$  ppm are detrimental. Removal of organisms from effluent was achieved by sand filtration, and

inoculation occurred by backwashing with mineralized influent. Temp. changes between 16° and 24° had no effect. Cultures acclimatized to 1,000-ppm phenol destroyed similar concns. of *o*-, *m*-, and *p*-cresols.—*CA*

### Determination of the Lethal Activity of Chlorine and Ozone on *Esch. coli*.

G. BRINGMANN. *Z. Hyg. Infektionskrankh. (Ger.)*, 139:130 ('54). Effect of Cl on *Esch. coli* was investigated quantitatively in closed system of 1-l vol. Well buffered medium prevented shift of pH and guaranteed stable Cl content. For detn. of effect of ozone, cells were suspended in distd. water at pH 6.2. Mode of action of Cl and of ozone differs. With ozone, in contrast to Cl, there is general oxidation of cytoplasm and not selective injury to vital centers. Active Cl, 0.1 mg/ml, required 4 hr and 10 min to kill 60,000 *Esch. coli* cells, while 0.1 mg/l ozone required only 5 sec. When temp. raised from 22° to 37°, time required for ozone was approx. 0.5 sec.—*CA*

### The Effect of Flaming of Taps Before Sampling on the Bacteriological Examination of Farm Water Supplies.

S. B. THOMAS ET AL. *J. Appl. Bact. (Br.)*, 17: 2:175 (Oct. '54). Flaming of taps before sampling caused no signif. differences in MPN of coli-aerogenes organisms or *Esch. coli* in water samples, or in colony counts at 37° or 22°, though there was tendency for bact. content to be lowered.—*BH*

*Esch. coli*, Types 0111 and 055, in Drinking-Water Supplies. P. MONNET ET AL. *Ann. Inst. Pasteur (Fr.)*, 87:3:347 (Sep. '54). It is now well known that certain strains of *Esch. coli* cause infant gastroenteritis. Authors have been searching for these particular strains in water supplies.

(Continued on page 64)



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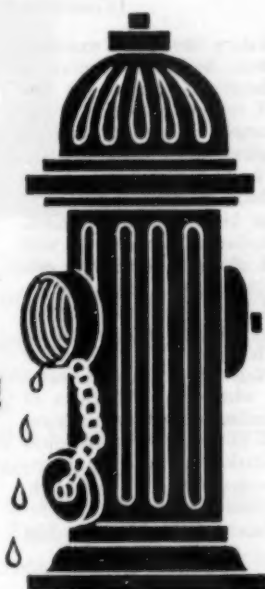
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(Continued from page 62)

Altogether, 605 waters have been examined, including river, well, and main waters in central and southeastern France. In one instance, *Esch. coli*, type 111: B4 was recovered. From 54 samples examined in northern France, one contained *Esch. coli*, 55: B5. *Esch. coli*, 111: B4 was found in main water along with other bact. evidence of poln. following breakdown in chlorination. *Esch. coli*, 55: B5 was isolated from shallow well water; other signs of faecal poln. were evident. Like other pathogenic intestinal organisms, strains of *Esch. coli* causing gastroenteritis in infants can be transmitted by water. It would be interesting to ascertain whether these strains are present in water supplies of areas where sporadic cases of disease occur. Finding of pathogenic serotype of *Esch. coli* in main water indicates necessity of installation of adequate treatment to preserve consumers from such risk. Identification of these *Esch. coli* types requires complete biochem. study and often serological examn.—BH

**A Comparison of the Membrane Filter With the Most Probable Number Method for Coliform Determination From Several Waters.** E. L. SHIPE & G. M. CAMERON. Applied Microbiol., 2:2:85 ('54). Experiment has been described in which 2 methods of coliform determination, namely, MPN and membrane filter methods, have been compared. Varying numbers of pure culture of *Esch. coli* cells were inoculated into 3 types of water: raw river water, dechlorinated tap water, and double-distilled water. There was definite loss in number of viable cells, which was particularly marked in river water, owing possibly to toxic effect of diluted effluent in this water. Loss of cells upon standing appeared to be greater in waters of low cell concentrations than in those of high cell concentrations, possibly owing to transfer of nutriment from original broth culture with higher cell concentrations. Overall difference in 2 methods of coliform determination was most marked with river water. Accumulation of toxic substances

(Continued on page 66)

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## ARMCO WELDED STEEL PIPE



(Continued from page 64)

on membranes could be possible explanation, or it may be that attenuated cells recover more readily in liquid environment than under conditions of growth on membrane.—BH

**Membrane Filter and Emergency Water Supply Control.** G. V. LEVIN & E. J. LAUBAUSCH. *Am. J. Pub. Health*, 44:55 ('54). Provision of emergency water supply to railway sleeping cars parked in sidings and used for accommodating delegates at presidential inaugural celebration at Washington in 1953 gave excellent opportunity for testing membrane filter method of bact. anal. of water. 200 samples were tested by multiple-tube stand. method and membrane filtration method. Only 11 samples produced gas in lactose broth within 48 hr. Of these, 3 were positive in confirmed test, and 2 of these 3 cases were only ones from which coliform colonies developed on membranes by membrane filter technique. It is reported that this is first emergency field application

of membrane filter in US. Details are given of arrangements made for supply and chlorination of water to the 299 sleeping cars, parked in 5 railway sidings, during this celebration.—BH

**Water Bacteriology—Problems and Possibilities.** W. SCHWARTZ. *Gas- u. Wasser-fach (Ger.)*, 95:443 ('54). Water bacteriology deals at present mainly with sanitary approval of drinking water, depending on coliform and total count on agar or gelatine. Various difficulties of interpretation are solved by differential tests, although this does not explain atypical forms. Thus, standards have been established which may be satisfactory from medical standpoint in connection with local inspection. This method, however, does not study water itself as it comes from springs, wells, or surface sources. Many of these waters show low count on standard media, although special media show that they contain many other organisms—for example, soil bacteria.

(Continued on page 70)

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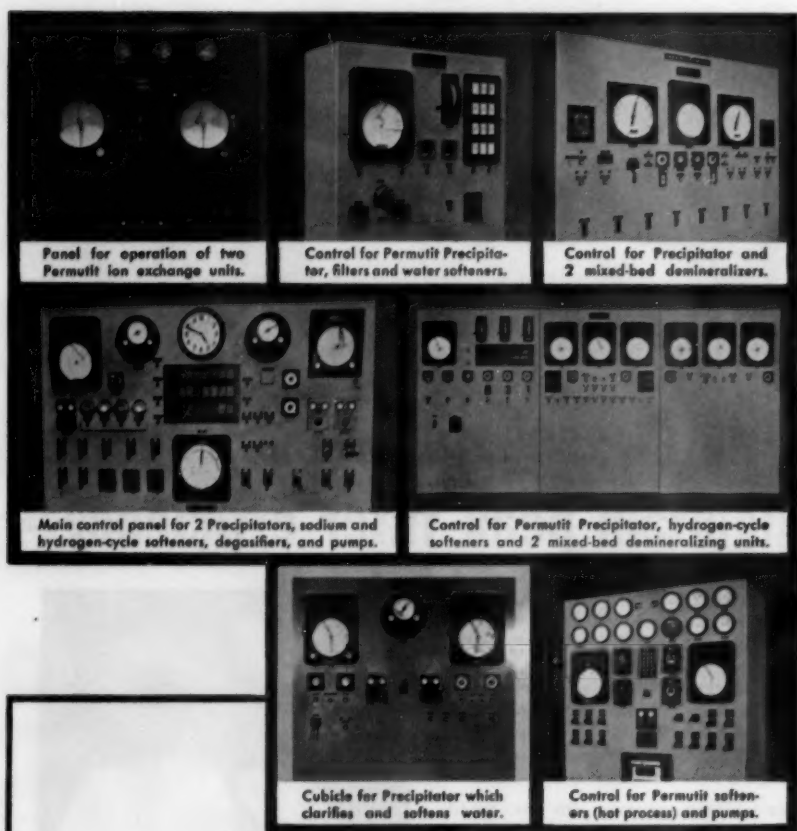
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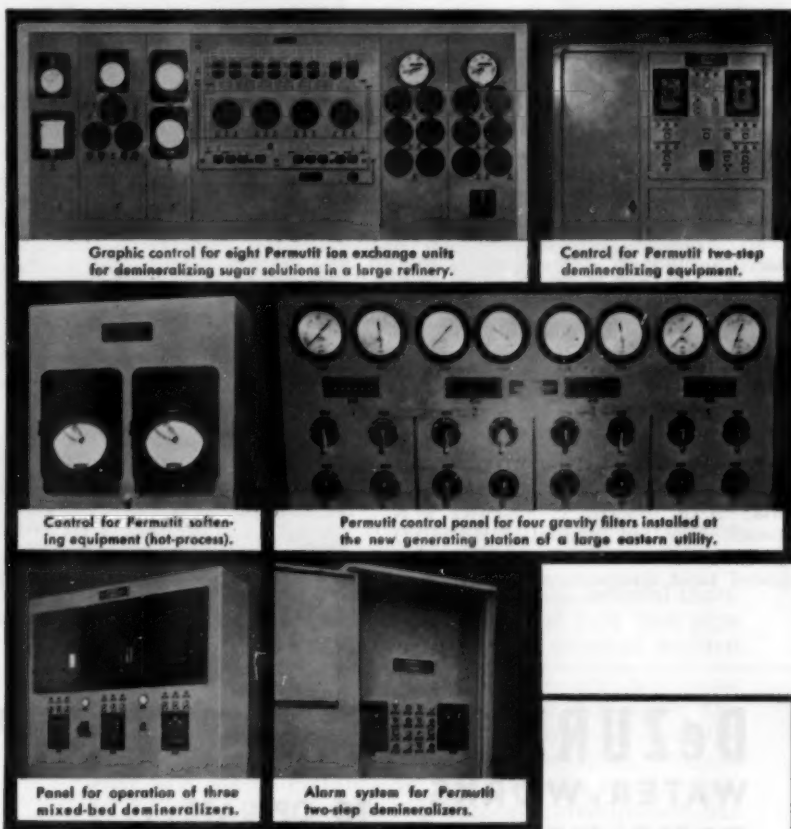


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(Continued from page 66)

Studies on well waters from different strata or formations show that some bacteria are present regularly, while others are peculiar to certain formations. In surface waters, there is greater variety. Little work has been done along these lines, as well as on marine bacteriology and on study of such special groups as sludge formers, zoogaea, sulfur organisms, organisms in thermal waters, and others. Many microorganisms other than bacteria also need investigating, and microbiological corrosion, as well as mine waters, furnishes wide field of research. Scope of water bacteriology is, therefore, much larger than sanitary tests; should properly include whole field of microbiology.

—M. Suter

**An Interpretation of the BOD Test in Terms of Endogenous Respiration of Bacteria.** S. R. HOOVER, L. JASEWICZ & N. PORGES. *Sew. Ind. Wastes*, 25:1163 ('53). Expts. on biochem. oxidation of dairy wastes showed rapid disappearance, usually in 24

hr, of sol. substrates in BOD bottle. If seeded at optimum, bacterial count also reached max. in approx. 24 hr. Reference to bacteriol. literature indicated that commonly accepted  $k=0.1$  corresponds to endogenous respiration rate of many common aerobic organisms. BOD test consists of [1] rapid growth of cells with assimilation of available nutrients into cells; and [2] subsequent slow endogenous respiration of these cells. Step 1 is completed in max. of 24 hr and step 2 prevails throughout major portion of test period. Whenever unimol. reaction rate with  $k=0.1$  is approximated in BOD test, reaction is solely one of endogenous respiration.—CA

**The Effect of Storage on Coli-Aerogenes and *Bacterium coli* Counts of Samples on Nonchlorinated Water Supplies.** S. B. THOMAS. *Lab. Practice*, 3:331 ('54). Results of recent studies on effect of storage between collection and examn. of water sam-

(Continued on page 72)

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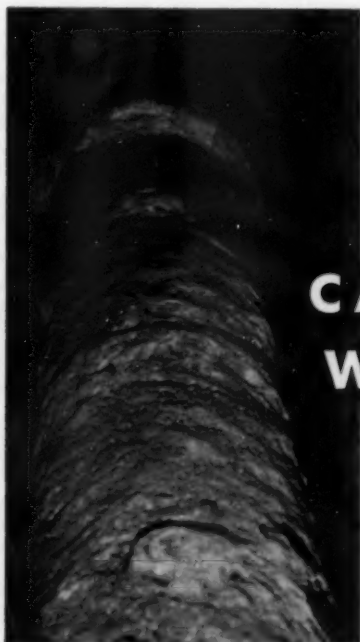
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(Continued from page 70)

ples reported and discussed. Overnight storage, even at 0°-5°C., may cause signif. changes in bact. content, and, owing to decreased counts sometimes recorded, can result in acceptance of supplies not really safe. Effects of storage may depend on nature of water (surface or underground) and on degree and time of bact. poln., which varies according to source (reservoir, river, or farm supplies). Ingestion of bacteria by protozoa, destruction by antibiotics during storage, or presence of Cu can give lower counts. Samples should be examd. within 6 hr after collection and should be kept at -5°C during transport.  $\text{Na}_2\text{S}_2\text{O}_8$  in sampling bottles inhibits any change in real no. of bacteria; 0.1 ml of aq. 3%  $\text{Na}_2\text{S}_2\text{O}_8$  in 6-oz bottle (0.3 ml in 18-oz bottle) does not affect appreciably counts of *Esch. coli* and *coli-aerogenes* of nonchlorinated water supplies after storage for 6 hr at 5°C.—PHEA

**Infrared Spectrophotometry of Enteric Bacteria.** S. LEVINE ET AL. J. Bact., 65:10 ('53). Authors discuss use of infrared

spectrophotometry in study of bacteria. Infrared spectra of enteric bacteria *Aerobacter aerogenes*, *Esch. coli*, *Salmonella montevideo*, and *Shigella dysenteriae* are shown and use of these spectra for identification of bacteria is indicated. From study of spectra of bact. extracts and fractions it is concluded that absorption band occurring at  $8.0\mu$ - $8.1\mu$  is due largely to presence of nucleic acid. Broad absorption band occurring at  $8.6\mu$ - $10.0\mu$  is due to presence of both nucleic acids and carbohydrates. Changes in medium on which bacteria are grown may often cause definite changes in bact. spectrum.—WPA

**Filtering Methods for the Demonstration of *Salmonella* Bacteria in Water.** V. LJUTOV. Acta Pathol. Microbiol. Scand. (Denmark), 35:370 ('54). In this paper, 2 filter methods are compared with enrichment methods for demonstration of *Salmonella* organisms in water. Best results obtained by transferring membrane or "Super-

(Continued on page 74)

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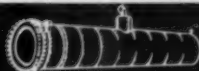
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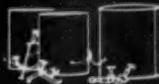


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(Continued from page 72)

cel" charged with bact. to solid media rather than by using enrichment media. Supercel method was particularly sensitive; for example, by placing supercel on solid medium, no. of pathogenic bacteria in water sample could be detd. and as few as 5-6 pathogenic microorganisms could be detected in 20 l of tap water. Water is rapidly and reliably filtered and, compared with membranes, materials (Supercel and textile fabric) are inexpensive and easy to acquire. During *Salmonella* epidemic in Sweden in 1953, 348 water specimens were examd., of which 22 were positive. Of these 348 specimens, 318 were examd. by Supercel method which gave positive results in 19 cases. Among latter, 8 specimens contained only 3-15 *Salmonella* bacteria/l.—BH

**Concentration Technique for Demonstrating Small Amounts of Bacteria in Tap Water.** E. HAMMARSTROM & V. LJUTOV. Acta Pathol. Microbiol. Scand. (Denmark), 35:365 ('54). This paper compares 2 types of filter: membrane filter manufactured in Göttingen, Germany, and filter made up of

pulverized diatomaceous earth held on cotton textile fabric (38 threads/cm). Filtration through membranes is sometimes slow when relatively large vols. of water are involved and particularly if water is of very poor phys. qual. Greatly increased rates of filtration were obtained when membrane was replaced by textile fabric covered with fine layer of diatomaceous earth in varying thicknesses from 5 to 50 mg/sq cm effective filter surface. Vols. filtered in 30 min were over 100 l and bact concn. achieved varied between 25,000 and 50,000 times.—BH

**Bacteriological Examination of Water by Membrane Filtration.** B. KARAKASEVIC. Z. Hyg. Infektionskrankh. (Ger.), 140:457 ('54). Over 450 water samples consisting of almost equal nos. in each of 3 groups from pold., heavily pold., and drinking-water sources were examd. for coliform bacteria by various methods. Media examd. were lactose, broth, lactose peptone water with Andrade indicator, BGB and MacConkey broth; results of these were compared with

(Continued on page 76)



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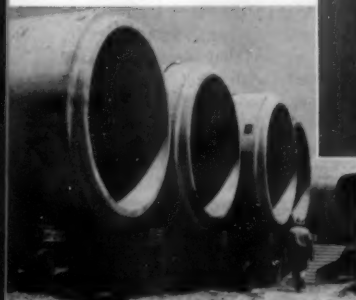
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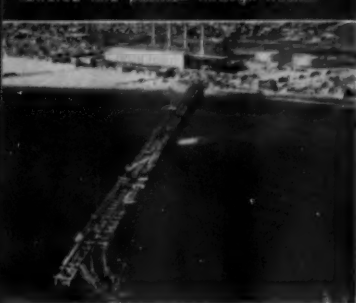
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Temporary trestle provides runway for gantry crane. Pipe sections are lowered into position through trestle.



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(Continued from page 74)

colonies produced on membranes by means of membrane filtration method. Generally, higher coliform counts were obtained by membrane filter method than by any selective liquid method. In addition, there were fewer false presumptives by membrane filter method; for example, avg of 3.8 per cent., compared with 13-15 per cent in case of liquid media. Comparable results were also obtained in the detn. of total bact. count by conventional agar plate method and by membrane filtration method. Authors conclude that membrane filtration is more dependable and more exact for establishing presence of coliform organisms in water and for the detn. of total bact. content of water samples. Besides, it is more rapid, simpler, and cheaper. —BH

**Streptococci as Indices of Pollution in Well Waters.** W. MORRIS & R. H. WEAVER. *Appl. Microbiol.*, 2:282 ('54). Duplicate samples were collected from 52 wells in Fayette County, Ky., iced, and taken immediately

to laboratory. MPN values for coliform organisms and streptococci were determined on one of each pair of samples at once and on other after 24-hr storage at room temperature. Numbers of coliform organisms and streptococci in well waters were found to be identical, on average. Coliform and streptococci bacteria were found to be of equal value as index organisms for detecting presence, absence, or extent of pollution in freshly collected well water samples. Both tests gave results which correlated well with what was known about location and construction of wells from which samples came. For examination of stored samples, as test for streptococci appeared to be slightly superior, numbers of streptococci never increased in sample, while numbers of coliform organisms might either increase or decrease. When either coliform bacteria or streptococci disappeared from stored sample, other did likewise, so that false negative would be obtained with test for either. Test for streptococci requires less time and fewer materials. —PHEA



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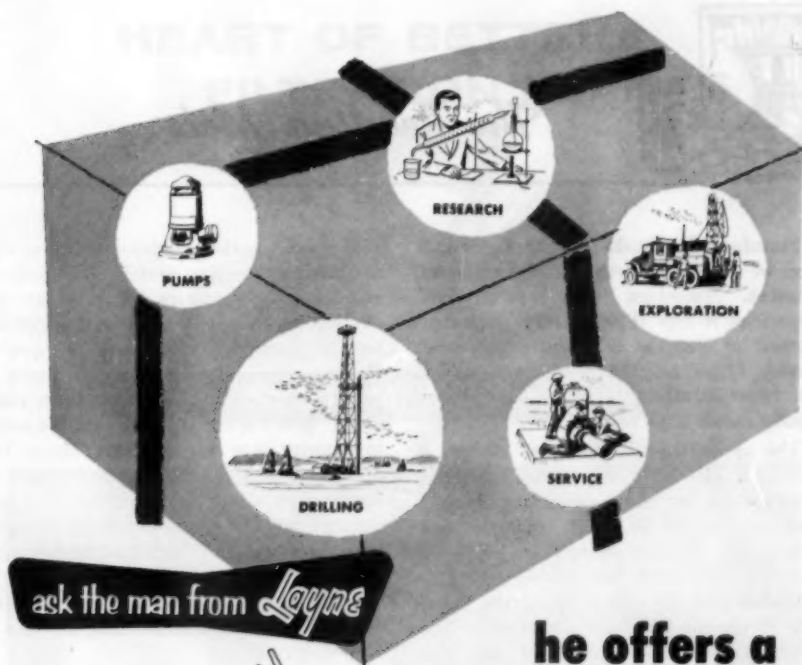
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**Standard Methods for the Examination of Water, Sewage, and Industrial Wastes.** *American Public Health Assn., American Water Works Assn., and Federation of Sewage & Industrial Wastes Assns. (10th ed., 1955) 522 pp.; \$7.50 (\$6.50 to members of above associations sending cash with order)*

The appearance of the tenth edition of *Standard Methods* represents a great achievement by the cooperating organizations. In the 50 years since the first appearance of the volume in 1905, the scope of the work has continually been extended and the character of the scientific treatment has been improved. The tenth edition has almost 80 per cent greater volume than the ninth. The plan and arrangement of the material have been much improved. The scientific level of the discussions of the procedures and of the directions for their performance is considerably raised. For trained scientists in well equipped laboratories, the treatment is magnificent. Unfortunately many of those who will be required to use these procedures are not highly trained and do not have laboratories which are elaborately equipped. For them the tone of the book may seem too high. It may be confusing. But it will be necessary for them to follow the instructions accurately if they are to benefit by the quasilegal acceptance which the standard methods enjoy almost universally in the courts.

The book is divided into six parts. The first four parts are concerned with the physical and chemical examination of: [1] natural and treated waters in the absence of gross pollution; [2] sewage, treatment plant effluents, and polluted waters; [3] industrial wastes; and [4]

sludge and bottom sediments in sewage treatment processes and in polluted rivers, lakes, or estuaries. Part 5 concerns routine bacteriologic examinations of water to determine its sanitary quality. Part 6 covers biologic examinations of water, sewage sludge, and bottom materials. Much space is devoted to the newer instrumentation procedures. Many new procedures are introduced and some old methods of analysis are deleted, but procedures for the measurement of radiation in waters will not be found in *Standard Methods* at this time. [This review, by Jack J. Hinman Jr., is reprinted from the June 1955 issue of *American Journal of Public Health*.]

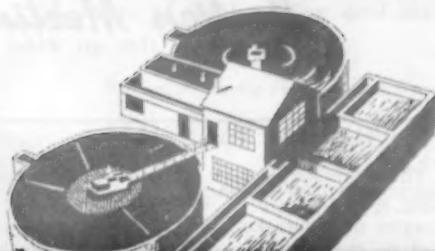
**The Black River Drainage Basin: Recommended Classifications and Assignments of Standards of Quality and Purity for Designated Waters of New York State.** *Water Pollution Control Board, New York State Dept. of Health, Albany 1, N.Y. (1953) 198 pp.; paper-bound; free*

In addition to recommended classifications, this report includes the results (in tables and graphs) of stream flow and quality studies of the Black River Basin in northwestern New York.

**Lower Esopus Creek Drainage Basin.** *Lower Hudson River Survey Series, Report No. 7. Water Pollution Control Board, New York State Dept. of Health, Albany 1, N.Y. (1954) 36 pp.; paper-bound; free*

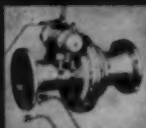
Recommended classifications and assignments of standards of quality and purity are given, as well as analytical results.

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## Section Meetings

**Nebraska Section:** The Nebraska Section, which meets jointly with the Utilities Section of the League of Nebraska Municipalities, returned to the two-day meeting plan (plus the preceding evening) in carrying out its activities this year. In 1954 the meeting was three days in length, with a number of section-financed (nonallotment, of course) activities. The expenditures proved to be larger than could be supported year after year.

This year's program was launched quite adequately on Wednesday evening, Apr. 13, with entertainment furnished by the city of Wilber in honor of its mayor. A Bohemian band, Wilber weiners, beer, and a long list of victual supplements was supplied. Those folks down in Wilber pursue fun and frolic just as vigorously as they work.

The two-day technical program included these presentations: "The Future of the Electrical Industry" by Harold

(Continued on page 82 P&R)



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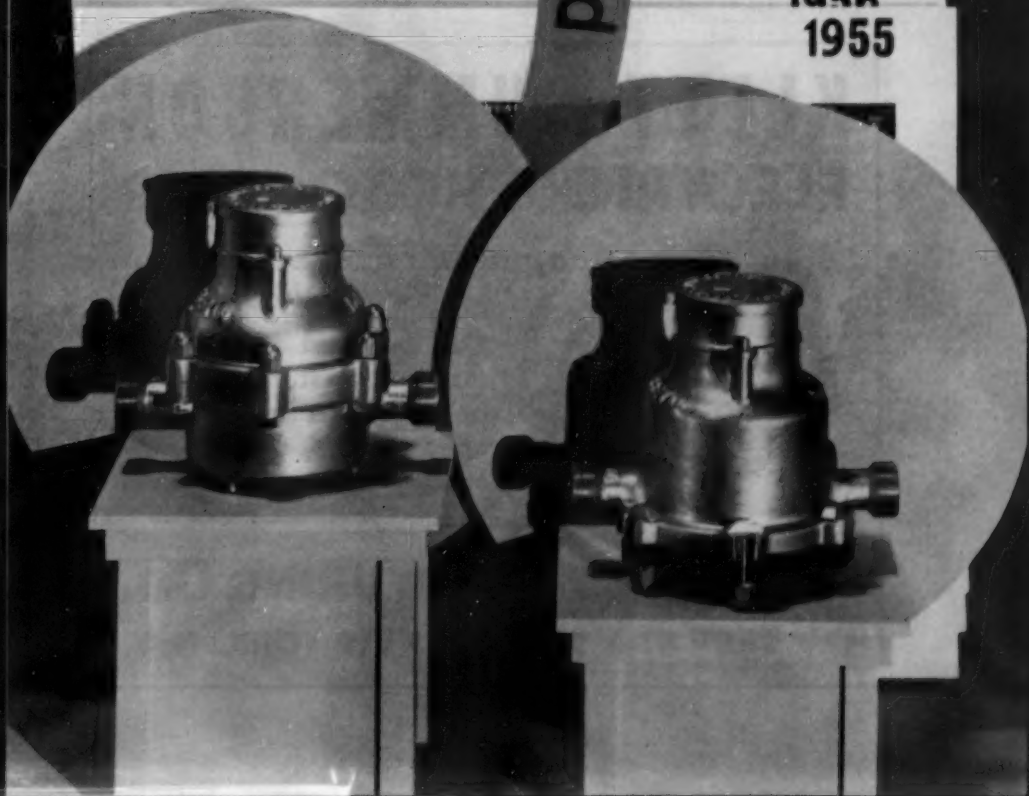
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1955



**Section Meetings***(Continued from page 80 P&R)*

Lutton, Westinghouse Electric Supply Co., New York; "Establishing Utility Rates and Service Charges" by W. B. Avery, city manager, Manhattan, Kan.; "Public Relations in Our Utilities" by Alex Radin, general manager, American Public Power Assn., Washington, D.C.; "It's the Little Things That Count" by Larry Clark, superintendent, Broken Bow; "Nebraska Section Committee Report on Air-conditioning Water Use" by George R. Miller, general manager of utilities, Beatrice; Two-Way Radio Communications for Our Utilities" by Paul Feistner, superintendent of distribution, Omaha Public Power Dist.; "Digest of 1955 Legislative Bills Affecting Our Utilities" by Victor Bremer, mayor, Nebraska City; "Methods Available for Financing Sewage Treatment Plants" by W. W. Nuernberger, former attorney, League of Nebraska Municipalities; "Re-

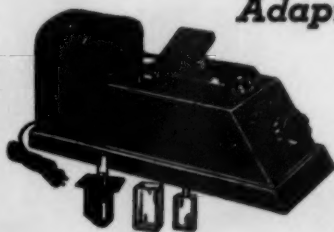
mote Automatic Control of Pumping Equipment" by George Doyle, engineer, Northern Natural Gas Co., Omaha; "Panel Discussion—Trends in Electrical Rates and Types of Service," C. H. Hoper (moderator), consulting engineer, Denver, Colo.; D. R. Hill, manager of utilities, Hastings; G. R. Miller, manager of utilities, Beatrice; Clarence Minard, assistant general manager, Omaha Public Power Dist.; and M. L. Sievers, manager of utilities, North Platte; "Development of Deep Well Turbine Pumps" by A. O. Fabrin, chief engineer, Layne & Bowler, Inc., Memphis, Tenn.; and a film, "Clean Waters," shown by Richard Scott, General Electric Co., Lincoln.

The Thursday evening banquet was highlighted by the presentation of the section's certificate of appreciation to the outgoing chairman, Bert Gurney of Omaha, together with presentation by

*(Continued on page 84 P&R)*

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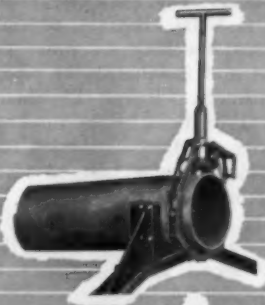
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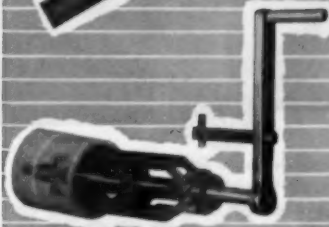
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**Section Meetings***(Continued from page 82 P&R)*

AWWA Secretary Jordan of the Association's "Mr. Ten Thousand" certificate to Ferd Merritt, superintendent of water, Chadron. The banquet was featured by an excellent address, with color slides, on "Some Observations on the Educational Mission to Turkey" by Dean Roy M. Green, College of Engineering & Architecture, University of Nebraska. He explained the arrangement which the university has with the Turkish government in assisting in the establishment of the new Ataturk University in eastern Turkey.

E. BRUCE MEIER  
Secretary-Treasurer

**New York Section:** The New York Section held its annual spring meeting at the Hotel Statler, Buffalo, on Apr. 20-22, 1955. The total registration was 315. George E. Symons, consultant and technical editor, Larchmont, opened the water

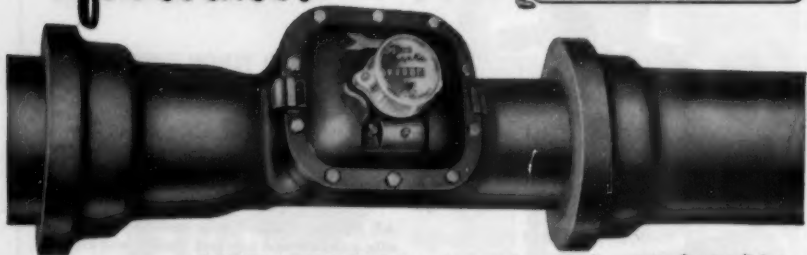
works school meeting on Thursday with an interesting talk on the design and construction of the distribution system. Raymond Murray, engineer, Nussbaumer, Clarke & Velzy, Buffalo, continued this discussion, touching on water main extensions and installation of pipe, valves, and hydrants. Joseph L. Shed, superintendent of lines, Erie County Water Authority, Buffalo, concluded the morning session with a talk on testing and disinfecting of water mains.

Albert Klaus, city treasurer, Buffalo, gave the address of welcome at the luncheon. A special ladies' luncheon was held at the Rainbow Room, at the Sheraton-Brock Hotel, Niagara Falls, Canada. Prior to the luncheon, the ladies had a sightseeing tour of the falls.

F. W. Gilcreas, assistant director of laboratories and research, State Dept. of Health, Albany, presented a paper (pre-

*(Continued on page 86 P&R)*

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**Section Meetings**

(Continued from page 84 P&amp;R)

pared in conjunction with Dr. Sally M. Kelly of the state health department) on the relation of the coliform test to virus pollution (*see this issue*, p. 683). Following Mr. Gilcreas' talk, A. Y. Hyndshaw, West Virginia Pulp & Paper Co., Tyrone, Pa., presented a paper on "Some Recent Experiences in Taste and Odor Control." A. J. Frank, vice-president and general manager, National Water Main Cleaning Co., New York, concluded the technical session with an interesting paper on "Maintaining Capacity of Water Mains." Cocktails were served through the courtesy of the Water & Sewage Works Manufacturers Assn. An accordion player provided music and songs which were enjoyed by all.

Following the banquet, AWWA Secretary Jordan presented the 1955 Fuller Award to Evan A. Sigworth and Life Member certificates were presented to Alfred M. Roberts, Hamburg; E. J. Van

Dusen, Malone; R. Gordon Yaxley, Waterford; Edwin W. Hopkins, Rensselaer County; and Eugene A. Hardin, New York. John J. Meehan, city engineer, Schenectady, was elected as the new trustee for 1955. Entertainers, consisting of a magician, a dance team, vocalists, and a comedian, provided a good show, and dancing continued until midnight.

The round-table conference on Friday morning was led by Nelson M. Fuller, general superintendent, Batavia. The following topics were discussed: location of reinforcing mains in distribution systems, water main cleaning experiences, collection of water bills, and fluoridation.

Friday afternoon was devoted to an inspection trip to the City of Niagara Falls' new pumping station and water filtration plant and to Tonawanda's filter plant, which is now under construction.

KIMBALL BLANCHARD  
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## CHANGES IN MEMBERSHIP

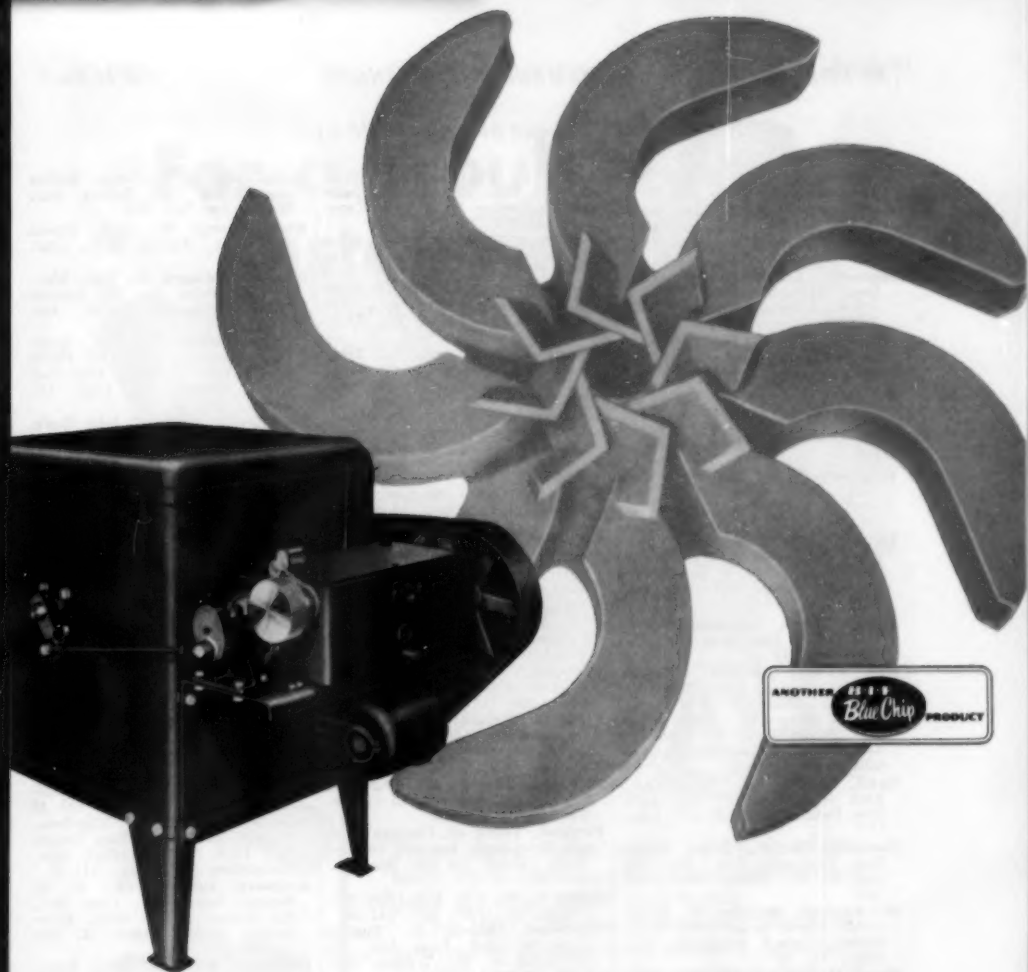


## NEW MEMBERS

Applications received May 1-31, 1955

- Almand, Charles F.**, Sales Engr., Allen-Shuff Corp., 3651 Aurora Circle, Memphis 11, Tenn. (Apr. '55) *P*
- Anderson, Robert H.**, Cons. Engr., 16 E. Main St., St. Charles, Ill. (Apr. '55) *RP*
- Atkinson, W.**; see Greensburg (Kans.)
- Aydellott, William R.**, Pres., Pekin Water Works Co., Pekin, Ill.
- Barton, Edwin J.**, Civ. Engr., O'Brien & Gere, 400 E. Genesee St., Syracuse, N.Y. (Apr. '55) *MRPD*
- Beaudry, Maurice**, Engr., Gohier Dorais, 333 Craig E., Montreal, Que. (Apr. '55)
- Belcher, Robert J.**, Water Supt., Fultondale, Ala. (Apr. '55) *MD*
- Benedict, Irvin J.**, Sanitation Supervisor, Water Board, 106 W. Market St., Box 2449, San Antonio, Tex. (Apr. '55) *P*
- Bergerson, R. K.**; see Ground Water Inst.
- Berrier, Jack E.**, Mech. Engr., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Apr. '55)
- Blair, James W.**, City Engr., City Hall, Statesboro, Ga. (Apr. '55)
- Borchers, Harry J., Jr.**, Mgr., North Wales Water Authority, Box 174, North Wales, Pa. (Apr. '55) *M*
- Bourret, Jean-Paul**, Chief Engr., Bureau of Water Supply & Highways, Levis, Que. (Apr. '55)
- Brewer, Hugh H.**, Comr. No. 2, Dept. of Public Works, Fort Smith, Ark. (Apr. '55) *MRPD*
- Broomfield Heights Mutual Service Assn.**, K. C. Ensor, Pres., Box 47, Broomfield, Colo. (Corp. M. Apr. '55) *MRPD*
- Brown, C. Carter**, Partner, Brown & Butler, Box 605, Baton Rouge, La. (Apr. '55) *MRPD*
- Byrd, Paul R.**, Cons. Engr., Byrd Eng. Co., Merchants & Planters Bank Bldg., West Memphis, Ark. (Apr. '55) *M*
- Chastain, E. M.**, Cons. Engr., Chastain, Francis & Assocs., 155 W. Main St., Decatur, Ill. (Apr. '55) *MRP*
- Clyde Board of Trustees of Public Affairs**, H. A. Einhart, Mgr., 606 S. Church St., Clyde, Ohio (Apr. '55) *MRP*
- Colvin, Edward A.**, Chief Operator, Public Utilities Com., 100 Simcoe St., Oshawa, Ont. (Apr. '55)
- Crippen, George B.**, Utilities Mgr., St. Paul Park, Minn. (Apr. '55) *M*
- Davis, J. Freeman**, Salesman, Neptune Meter Co., 1803 Finance Bldg., Philadelphia, Pa. (Apr. '55) *MRPD*
- Dement, John C.**, Gen. Supt., Disposal Plant & Warehouse, Maplewood Housing Corp., Box 2595, Maplewood, La. (Apr. '55) *M*
- Detectron Corp.**, Stanley F. Gotter, Director, Pipe Detector Div., 5528 Vinceland Ave., North Hollywood, Calif. (Assoc. M. Apr. '55)
- Dimmitt, Donald E.**, Supt., Water Service Production, Southern California Water Co., 5646 Priory St., Bell Gardens, Calif. (Apr. '55) *RPD*
- Droke, J. W.**, Owner, J. W. Droke & Assocs., Box 2525 Carter Field Stn., Fort Worth, Tex. (Apr. '55)
- Durrett, T. E., Jr.**, Gen. Mgr., Radnor Water Dist., 2229 Nolensville Rd., Nashville, Tenn. (Apr. '55) *M*
- Einhardt, H. A.**; see Clyde (Ohio) Board of Trustees of Public Affairs
- Ellis, P. T.**, Oklahoma Field Repr., United Industries Inc., 813 W. 2nd, Wichita 12, Kans. (Apr. '55)
- Ensor, K. C.**; see Broomfield Heights (Colo.) Mutual Service Assn.
- Fargo, Roman C.**, City Engr., Glasgow, Mont. (Apr. '55) *M*
- Feld, James Wyatt**, San. Engr., Office, Chief of Engrs., US Army, Washington, D.C. (Apr. '55) *RP*
- Ferguson, Virgil B.**, Field Engr., The Pitometer Assn., 1545 Crestview Dr., Pittsburgh 2, Pa. (Apr. '55) *D*
- Flattery, John T.**, Acting Asst. Supt., Water Dept., Medina, N.Y. (Apr. '55) *MRPD*
- Fujita, Francis I.**, Mgr., Water Sales Div., Board of Water Supply, Box 3410, Honolulu 1, Hawaii (Apr. '55) *MRPD*
- Gaines, M. L.**, Supt., Forest Lakes Water Works, 4813 Forest Dr., Columbia, S.C. (Apr. '55)
- Gattenmeyer, John L.**, Corrosion Engr., Canadian Protective Coating Ltd., 9336-91st St., Edmonton, Alta. (Apr. '55) *PD*
- Gausch, Joseph K.**, Salesman, Alabama Pipe Co., 122 S. Michigan Ave., Chicago 3, Ill. (Apr. '55) *MP*
- Gevorgian, Vigen**, Co-Chief, San. Eng. Div., Public Health Co-operative Organization, Tehran Area, Ministry of Health, Shah-Reza Ave., Fetoohi St., Shick Tehran, Iran (Apr. '55) *RD*
- Gluck, Richard B.**, Asst. Supt., Water Dept., City Hall, Vine & Cajon St., Redlands, Calif. (Apr. '55) *MRPD*
- Gotter, Stanley F.**; see Detectron Corp.
- Green, H. Kermit**, Comr., North Jersey Dist. Water Supply Com., Wanaque, N.J. (Apr. '55) *M*
- Greensburg, City of**, W. Atkinson, Light & Water Supt., 113 W. Florida, Greensburg, Kans. (Corp. M. Apr. '55) *MRD*
- Griffin, Clifford E.**, Comr., Public Works, 111 Mechanic St., Fayetteville, N.Y. (Apr. '55) *MRPD*
- Ground Water Inst.**, R. K. Bergerson, Secy.-Treas., Box 981, Minneapolis 1, Minn. (Corp. M. Apr. '55)
- Hanna, George P., Jr.**, Engr., Tech. Group, Creole Petroleum Corp., Apt. 172, Maracaibo, Venezuela (Apr. '55) *RPD*
- Harris, Robert R.**, San. Engr., Director, US Public Health Service, Water Supply & Water Pollution Control Program, Health, Education & Welfare Bldg., S. Washington, D.C. (Apr. '55) *RP*
- Henley, Laurel M.**, Asst. Chemist, State Water Survey Div., Urbana, Ill. (Apr. '55) *R*
- Hilbert, Robert**, Mgr., Salt Lake County Water Conservancy Dist., 124 E. 3900 S., Salt Lake City 7, Utah (Apr. '55) *MRPD*
- Hollister, Robert H.**, Salesman, Badger Meter Mfg. Co., 700 E. 27th St., Bryan, Tex. (Apr. '55)
- Hubbard, Stephen Roger**, Chief Engr., Cen-Vi-Ro Pipe Corp., 8610 Atlantic Ave., South Gate, Calif. (Apr. '55) *D*
- Husset, Elmer A., Jr.**, Assoc. Public Health Engr., Munic. Water Supply Sec., State Dept. of Health, University Campus, Minneapolis 14, Minn. (Apr. '55) *P*
- Ingenito, Frank P.**, Chemist, Water Dept., Queen Lane Purif. Plant, Queen Lane & Fox Sts., Philadelphia 29, Pa. (Apr. '55) *P*
- Ionson, C. C.**, Mgr. Public Utilities Com., 1210 Front Rd., La Salle, Ont. (Apr. '55)
- Ivie, O. H.**, Production Engr., Colorado River Munic. Water Dist., Box 869, Big Spring, Tex. (Apr. '55) *MRD*
- Jamison, J. R.**, Sales Repr., 3901 W. Platt St., Tampa, Fla. (Apr. '55) *P*
- Jones, J. W.**, Vice-Pres. & Mgr., Richland Township Water Co., 509-15th St., Windber, Pa. (Apr. '55) *M*
- Joy, Harlan C.**, Office Asst., R. W. Robinson Cons. Engr., 15216 Park Ave., Harvey, Ill. (Apr. '55) *M*
- Kasmarek, Robert J.**, Student, Univ. of Nebraska, 2819 Garfield St., Lincoln, Neb. (Apr. '55) *MRPD*
- Keefe, John**; see San Bruno (Calif.)
- Kelley, John E.**, Supt., Water Treatment Plant, Box 345, Oakley, Calif. (Apr. '55) *MRP*
- Kelly, Earl M.**, Pres., Process Engrs. Inc., 420 Peninsular Ave., San Mateo, Calif. (Apr. '55) *P*

(Continued on page 90 P&amp;R)



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(Continued from page 88 P&amp;R)

- Koerner, Joe A.**, Director of Service, Hays, Kan. (Apr. '55) *M*
- Kohl, Harry B.**, San. Engr., 3610th USAF Infirmary, Haringen Air Force Base, Tex. (Apr. '55) *RPD*
- Kotecki, Lawrence F.**, Cons. Engr., Samuelson & Co., 1004 E. 8th St., Fremont, Neb. (Apr. '55) *MRPD*
- Kovach, John J.**, Pump Operator, New Rochelle Water Co., New Rochelle, N.Y. (Apr. '55) *MRPD*
- Krueger, Forrest J.**, Eng. Mgr., National Aniline Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6, N.Y. (Apr. '55) *PD*
- Krueger, Louis C.**, Gen. Mgr., Butler Water Co., 120 E. Cunningham St., Butler, Pa. (Apr. '55) *M*
- Lawrence, Earl D.**, Supt., Pompano Beach Highlands Water & Sewer Dept., Rte. 1, Box 861-K, Pompano Beach, Fla. (Apr. '55) *MP*
- Leahy, Jack**, Salesman, Mueller Co., 538 W. Decatur St., Decatur, Ill. (Apr. '55)
- Lee, Luther Marvin**, Foreman, Water & Sewer Dept., Natchitoches, La. (Apr. '55) *M*
- Linton, Gene A.**, Sales Repr., Davis Meter Repair & Supply Co., 418-420 S. Madison St., Thomasville, Ga. (Apr. '55)
- Lynn, Charles F.**, Sales Engr., Lock Joint Pipe Co., Box 5008, Five Points, Columbia, S.C. (Apr. '55)
- Maccnell, W. C.**, Engr., McRea Eng. Equipment Ltd., 100 Adelaide St., W., Toronto, Ont. (Apr. '55)
- McLaughlin, Maurice M.**, Comptroller, North Jersey Dist. Water Supply Com., Wanaque, N.J. (Apr. '55) *M*
- Meng, Bernard Boyd, Jr.**, Supt., Board of Public Works, Winnsboro, S.C. (Apr. '55)
- Moore, J. W.**, Mgr., Pump Dept., Upton, Braden & James Ltd., 890 Yonge St., Toronto, Ont. (Apr. '55)
- Mowll, F. Pratapa**, Asst. Prof. of Civ. Eng., Eng. College, Jodhpur, Rajasthan State, India (Apr. '55) *MRPD*
- Nicholson, E. C.**, Supt. of Utilities, Kings Mountain, N.C. (Apr. '55) *MRPD*
- Norton, John J., Jr.**, Resident Engr., Freese & Nichols, 734 Chestnut St., Abilene, Tex. (Apr. '55) *MP*
- Oppenheim, Russell I.**, Pres., Magnamatic Corp. of America, 803 N. Main Ave., San Antonio, Tex. (Apr. '55) *D*
- Owings, Frank A.**, Supervisor, Credit & Collection Div., City Water Board, 106 W. Market St., Box 2449 San Antonio, Tex. (Apr. '55) *M*
- Paris Township Water Dept.**, B. G. Townner, Supt., 1661-44th St., S.E., Grand Rapids 8, Mich. (Munic. Sv. Sub. Apr. '55) *MRPD*
- Paulsen, Martin B.**, Asst. Personnel Director, American Water Works Service Co., 3 Penn Center Plaza, Philadelphia 3, Pa. (Apr. '55) *MD*
- Paulson, Clarence**; see Poulosbo (Wash.)
- Peterson, W. H.**, Mgr., Public Utilities Com., Port Dalhousie, Ont. (Apr. '55) *M*
- Pinkham, Chesley M.**, Chief Operator, Cachuma Operation & Maint. Board, 583 San Ysidro Rd., Santa Barbara, Calif. (Apr. '55)
- Pledger, James T.**, Water & Sewer Supt., Box 403, El Campo, Tex. (Apr. '55) *MR*
- Poulosbo, Town of**, Clarence Paulson, Town Supt., Box 444, Poulosbo, Wash. (Munic. Sv. Sub. Apr. '55) *MRPD*
- Price, J. K.**, City Mgr., Box 357, Crane, Tex. (Affil. Apr. '55) *M*
- Raymond, Anson J.**, Eastern Repr., Mitchell Press Ltd., 90 Richmond St. W., Toronto, Ont. (Apr. '55)
- Reed Mfg. Co.**, Campbell Wright, Vice-Pres., 1425 W. 8th St., Erie, Pa. (Assoc. M. Apr. '55)
- Robertson, I. A.**, Constr. Engr., Township of North York, Willowdale, Ont. (Apr. '55)
- Rodol, Robert B.**, Owner, Rolling Bay Water Co., Rolling Bay, Wash. (Apr. '55) *MD*
- Rose, George W.**, Supt., Alpena Power Co., Alpena, Mich. (Apr. '55)
- Rosella, Edward C.**, Dist. Mgr., Sparling Meter Co., 207 Queens Quay W., Toronto 1, Ont. (Apr. '55)
- Ryan, Matthew T.**, Supt., Belleville Reservoir, Dept. of Public Works, Div. of Water, City Hall Annex, Newark, N.J. (Apr. '55) *MP*
- San Bruno, City of**, John Keefe, City Mgr., City Hall, San Bruno, Calif. (Munic. Sv. Sub. Apr. '55) *M*
- Scott, Bernard W.**, Asst. Engr., Wyoming Township, 1155-28th St., S.W., Wyoming, Mich. (Apr. '55) *MP*
- Shaler, Clair A.**, Civ. Engr., Finkbeiner, Pettis & Strout, 518 Jefferson Ave., Toledo, Ohio (Apr. '55) *MRP*
- Shall, Philip B.**, Sales Engr., Thompson Equipment Co., 4020 Thalia St., New Orleans, La. (Apr. '55) *RPD*
- Shaw, John Arnold**, Resident Engr., Wemmershoek Pipeline, City Engr.'s Dept., Box 1694, Cape Town, South Africa (Apr. '55) *MR*
- Shearer, D. H.**; see Southern Cement Co.
- Smith, Thomas J.**, Supt. of Utilities, Pearsall, Tex. (Apr. '55) *M*
- Sollicito, Dominick**, Vice-Pres., Vincent Sollicito & Sons Constr. Co., Inc., 264 Guy Park Ave., Amsterdam, N.Y. (Apr. '55) *D*
- Southern Cement Co.**, D. H. Shearer, Sales Mgr., Lime Div., 602 Protective Life Bldg., Birmingham 3, Ala. (Assoc. M. Apr. '55)
- Stallings, Ward K.**, Mfrs. Repr., Ward K. Stallings Co., 1145 Peachtree St., Atlanta, Ga. (Apr. '55)
- Suetenfass, Melvin C.**, Public Health Engr., Public Health Dept., 128 W. Commerce St., San Antonio, Tex. (Apr. '55) *P*

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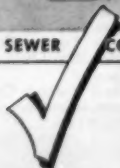
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Kennedy Valve Mfg. Co.  
Ludlow Valve Mfg. Co., Inc.  
M & H Valve & Fittings Co.  
Mueller Co.  
A. P. Smith Mfg. Co.  
Rensselaer Valve Co.  
R. D. Wood Co.

**Hydrogen Ion Equipment:**

Wallace & Tiernan Inc.

**Ion Exchange Materials:**

Cochrane Corp.  
General Filter Co.  
Graver Water Conditioning Co.  
Hungerford & Terry, Inc.  
Inflico Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.

**Iron, Pig**

Woodward Iron Co.

**Iron Removal Plants:**

American Well Works  
Chain Belt Co.  
Cochrane Corp.  
General Filter Co.  
Graver Water Conditioning Co.  
Hungerford & Terry, Inc.  
Inflico Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.  
Walker Process Equipment, Inc.  
Welsbach Corp., Ozone Processes Div.

**Jointing Materials:**

Hydraulic Development Corp.  
Johns-Manville Corp.  
Leadtite Co., Inc.

**Joints, Mechanical, Pipes:**

American Cast Iron Pipe Co.  
Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
Dresser Mfg. Div.  
Trinity Valley Iron & Steel Co.  
United States Pipe & Foundry Co.  
R. D. Wood Co.

**Leak Detectors:**

Jos. G. Pollard Co., Inc.

**Lime Slakers and Feeders:**

Dorr-Oliver Inc.  
General Filter Co.  
Inflico Inc.  
Omega Machine Co. (Div., B-I-F Industries)  
Permutit Co.

**Magnetic Dipping Needles:**

W. S. Darley & Co.

**Motor Boxes:**

Ford Meter Box Co.  
Pittsburgh Equitable Meter Div.

**Meter Couplings and Yokes:**

Badger Meter Mfg. Co.  
Dresser Mfg. Div.  
Ford Meter Box Co.  
Hays Mfg. Co.  
Hersey Mfg. Co.  
Mueller Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Welsbach Corp., Kitson Valve Div.  
Worthington-Gamon Meter Co.

**Meter Reading and Record****Books:**

Badger Meter Mfg. Co.

**Meter Testers:**

Badger Meter Mfg. Co.  
Ford Meter Box Co.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.

**Meters, Domestic:**

Badger Meter Mfg. Co.  
Buffalo Meter Co.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Well Machinery & Supply Co.  
Worthington-Gamon Meter Co.

**Meters, Filtration Plant,****Pumping Station,****Transmission Line:**

Builders-Providence, Inc.  
Fischer & Porter Co.  
Foster Eng. Co.  
Inflico Inc.  
Simplex Valve & Meter Co.

**Meters, Industrial, Commercial:**

Badger Meter Mfg. Co.  
Buffalo Meter Co.  
Builders-Providence, Inc.  
Fischer & Porter Co.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Simplex Valve & Meter Co.  
Well Machinery & Supply Co.  
Worthington-Gamon Meter Co.

**Mixing Equipment:**

Chain Belt Co.  
General Filter Co.  
Inflico Inc.

**Ozonation Equipment:**

Welsbach Corp., Ozone Processes Div.

**Paints**

Inertol Co., Inc.

**Pipe, Asbestos-Cement:**

Johns-Manville Corp.  
Keasbey & Mattison Co.

**Pipe, Brass:**

American Brass Co.

**Pipe, Cast Iron (and Fittings):**

American Cast Iron Pipe Co.  
Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
Trinity Valley Iron & Steel Co.  
United States Pipe & Foundry Co.  
R. D. Wood Co.

**Pipe, Cement Lined:**

Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
United States Pipe & Foundry Co.  
R. D. Wood Co.

**Pipe, Concrete:**

American Concrete Pressure Pipe Assn.

American Pipe & Construction Co.  
Lock Joint Pipe Co.

**Pipe, Copper:**

American Brass Co.

**Pipe, Steel:**

Alco Products, Inc.  
Armco Drainage & Metal Products, Inc.  
Bethlehem Steel Co.

**Pipe Coatings and Linings:**

The Barrett Div.  
Cast Iron Pipe Research Assn.  
Centrifline Corp.  
Inertol Co., Inc.  
Koppers Co., Inc.  
Reilly Tar & Chemical Corp.

**Pipe Cutters**

James B. Clow & Sons  
Ellis & Ford Mfg. Co.  
Jos. G. Pollard Co., Inc.

**Reed Mfg. Co.**

A. P. Smith Mfg. Co.  
Spring Load Mfg. Corp.

**Pipe Jointing Materials; see****Jointing Materials****Pipe Locators:**

W. S. Darley & Co.  
Jos. G. Pollard Co., Inc.

**Pipe Vises**

Spring Load Mfg. Corp.

**Plugs, Removable:**

James B. Clow & Sons  
Jos. G. Pollard Co., Inc.  
A. P. Smith Mfg. Co.

**Potassium Permanganate**

Carus Chemical Co.

**Pressure Regulators:**

Allis-Chalmers Mfg. Co.  
Foster Eng. Co.  
Mueller Co.

**Pumps, Boiler Feed:**

DeLaval Steam Turbine Co.

**Pumps, Centrifugal:**

Allis-Chalmers Mfg. Co.  
American Well Works  
DeLaval Steam Turbine Co.  
Morse Bros. Mch. Co.  
C. H. Wheeler Mfg. Co.

**Pumps, Chemical Feed:**

Inflico Inc.  
Proportioners, Inc.  
Wallace & Tiernan Inc.

**Pumps, Deep Well:**

American Well Works  
Layne & Bowler, Inc.

**Pumps, Diaphragm:**

Dorr-Oliver Inc.  
Morse Bros. Mch. Co.

**Pumps, Hydram:**

W. S. Darley & Co.  
Jos. G. Pollard Co., Inc.

**Pumps, Hydraulic Boosters:**

Ross Valve Mfg. Co.

**Pumps, Sewage:**

Allis-Chalmers Mfg. Co.  
DeLaval Steam Turbine Co.  
C. H. Wheeler Mfg. Co.

**Pumps, Sump:**

DeLaval Steam Turbine Co.  
C. H. Wheeler Mfg. Co.

**Pumps, Turbine:**

DeLaval Steam Turbine Co.  
Layne & Bowler, Inc.

**Recorders, Gas Density, CO<sub>2</sub>**

NH<sub>3</sub>, SO<sub>2</sub>, etc.:

Fischer & Porter Co.  
Permutit Co.  
Wallace & Tiernan Inc.

**Recording Instruments:**

Fischer & Porter Co.  
Inflico Inc.

**Reservoirs, Steel:**

Chicago Bridge & Iron Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Sand Expansion Gages; see****Gages****Sleeves; see Clamps****Sleeves and Valves, Tapping:**

James B. Clow & Sons  
M & H Valve & Fittings Co.  
Mueller Co.  
Rensselaer Valve Co.  
A. P. Smith Mfg. Co.

**Sludge Blanket Equipment:**

General Filter Co.  
Graver Water Conditioning Co.  
Permutit Co.

**Sodium Hexametaphosphate:**

Blockson Chemical Co.  
Calgon, Inc.

# Roberts Filter

*means...*

## MUNICIPAL WATER PURIFICATION



The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

## INDUSTRIAL WATER RECTIFICATION



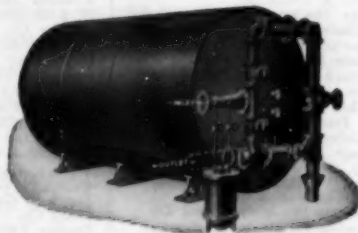
Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

## SWIMMING POOL RECIRCULATING SYSTEMS



The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

## PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

*When you think of good water—think of Roberts Filter*

MECHANICAL EQUIPMENT  
BY  
ROBERTS FILTER MFG. CO.

# Roberts Filter

Manufacturing Company • Darby, Penna.

**Sodium Silicate**  
Philadelphia Quartz Co.

**Softeners:**  
Cochrane Corp.  
Dorr-Oliver Inc.  
General Filter Co.  
Graver Water Conditioning Co.  
Hungerford & Terry, Inc.  
Inflico Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.  
Walker Process Equipment, Inc.

**Softening Chemicals and Compounds:**  
Calgon, Inc.  
Cochrane Corp.  
General Filter Co.  
Inflico Inc.  
Morton Salt Co.  
Permutit Co.  
Tennessee Corp.

**Standpipes, Steel:**  
Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Steel Plate Construction:**  
Alco Products, Inc.  
Bethlehem Steel Co.  
Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Stops, Curb and Corporation:**  
Hays Mfg. Co.  
Mueller Co.  
Welsbach Corp., Kitson Valve Div.

**Storage Tanks; see Tanks**

**Strainers, Suction:**  
James B. Clow & Sons  
M. Greenberg's Sons  
Johnson, Edward E., Inc.  
R. D. Wood Co.

**Surface Wash Equipment:**  
Cochrane Corp.  
Permutit Co.

**Swimming Pool Sterilization:**  
Everson Mfg. Corp.  
Fischer & Porter Co.  
Omega Machine Co. (Div., B-I-F Industries)  
Proportioners, Inc.  
Wallace & Tiernan Inc.  
Welsbach Corp., Ozone Processes Div.

**Tanks, Steel:**  
Alco Products, Inc.  
Bethlehem Steel Co.  
Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Tapping-Drilling Machines:**  
Hays Mfg. Co.  
Mueller Co.  
A. P. Smith Mfg. Co.

**Tapping Machines, Corp.:**  
Hays Mfg. Co.  
Mueller Co.  
Welsbach Corp., Kitson Valve Div.

**Taste and Odor Removal:**  
Cochrane Corp.  
Fischer & Porter Co.  
General Filter Co.  
Graver Water Conditioning Co.

**Industrial Chemical Sales Div.**  
Inflico Inc.  
Permutit Co.  
Proportioners, Inc.  
Wallace & Tiernan Inc.  
Welsbach Corp., Ozone Processes Div.

**Tenoning Tools**  
Spring Load Mfg. Corp.

**Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):**  
Wallace & Tiernan Inc.

**Turbines, Steam:**  
DeLaval Steam Turbine Co.

**Turbines, Water:**  
DeLaval Steam Turbine Co.

**Valve Boxes:**  
James B. Clow & Sons  
Ford Meter Box Co.  
M & H Valve & Fittings Co.  
Mueller Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.  
Trinity Valley Iron & Steel Co.  
R. D. Wood Co.

**Valve-Inserting Machines:**  
Mueller Co.  
A. P. Smith Mfg. Co.

**Valves, Altitude:**  
Ross Valve Mfg. Co., Inc.

**Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons  
DeZurik Shower Co.  
M. Greenberg's Sons  
M & H Valve & Fittings Co.  
Mueller Co.  
Henry Pratt Co.  
Kensselaer Valve Co.  
R. D. Wood Co.

**Valves, Detector Check:**  
Hersey Mfg. Co.

**Valves, Electrically Operated:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons  
Crane Co.  
Darling Valve & Mfg. Co.  
Kennedy Valve Mfg. Co.  
M & H Valve & Fittings Co.  
Mueller Co.  
Philadelphia Gear Works, Inc.  
Henry Pratt Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.

**Valves, Float:**  
James B. Clow & Sons  
Henry Pratt Co.  
Ross Valve Mfg. Co., Inc.

**Valves, Gate:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons  
Crane Co.  
Darling Valve & Mfg. Co.  
Dresser Mfg. Div.  
Kennedy Valve Mfg. Co.  
Ludlow Valve Mfg. Co., Inc.  
M & H Valve & Fittings Co.  
Mueller Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

**Valves, Hydraulically Operated:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons

Crane Co.  
Darling Valve & Mfg. Co.  
DeZurik Shower Co.  
Kennedy Valve Mfg. Co.  
M & H Valve & Fittings Co.  
Mueller Co.  
Philadelphia Gear Works, Inc.  
Henry Pratt Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

**Valves, Large Diameter:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons  
Crane Co.  
Darling Valve & Mfg. Co.  
Kennedy Valve Mfg. Co.  
Ludlow Valve Mfg. Co., Inc.  
M & H Valve & Fittings Co.  
Mueller Co.  
Henry Pratt Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

**Valves, Regulating:**  
DeZurik Shower Co.  
Foster Eng. Co.  
Mueller Co.  
Henry Pratt Co.  
Ross Valve Mfg. Co.

**Valves, Swing Check:**  
Chapman Valve Mfg. Co.  
James B. Clow & Sons  
Crane Co.  
Darling Valve & Mfg. Co.  
M. Greenberg's Sons  
M & H Valve & Fittings Co.  
Mueller Co.  
Kensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

**Waterproofing**  
Inertol Co., Inc.

**Water Softening Plants; see Softeners**

**Water Supply Contractors:**  
Layne & Bowler, Inc.

**Water Testing Apparatus:**  
Wallace & Tiernan Inc.

**Water Treatment Plants:**  
Allis-Chalmers Mfg. Co.  
American Belt Works  
Chain Belt Co.  
Chicago Bridge & Iron Co.  
Cochrane Corp.  
Dorr-Oliver Inc.  
Fischer & Porter Co.  
General Filter Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Hungerford & Terry, Inc.  
Inflico Inc.  
Permutit Co.  
Pittsburgh-Des Moines Steel Co.  
Roberts Filter Mfg. Co.  
Walker Process Equipment, Inc.  
Wallace & Tiernan Inc.  
Welsbach Corp., Ozone Processes Div.

**Well Drilling Contractors:**  
Layne & Bowler, Inc.

**Well Screens**  
Johnson, Edward E., Inc.

**Wrenches, Ratchet:**  
Dresser Mfg. Div.

**Zeolite; see Ion Exchange Materials**

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

## San Diego Prefers Concrete Pressure Pipe



Fast growing San Diego uses over 45,000,000 gallons of water each day, most of it supplied from reservoirs strategically located in the Incopah Mountain Range in back of the city. Concrete pressure pipe delivers nearly all this water to San Diego.

And San Diego continues to specify concrete pressure pipe. One of the latest installations in



this area was the Sweetwater extension to the San Diego aqueduct. Here, over 23,000 feet of 18-inch and 24-inch pipe was used to improve the water supply system.

Concrete pressure pipe provides maximum hydraulic capacity for extremely long periods of time. This, plus other outstanding advantages make it important for every city to investigate its use for water conduit systems.

*Member companies  
manufacture  
concrete pressure pipe  
in accordance with  
nationally recognized  
specifications*

# Concrete PRESSURE Pipe

**AMERICAN CONCRETE  
PRESSURE PIPE  
ASSOCIATION**

228 North LaSalle Street  
Chicago 1, Illinois

# Now it has been proved...

## The Exclusive Rockwell "O"-RING

### Water Meter Stuffing Box

### Nut Assembly

*Eliminates  
Stuffing Box  
Leaks, Binds,  
Troubles,  
Expense...*

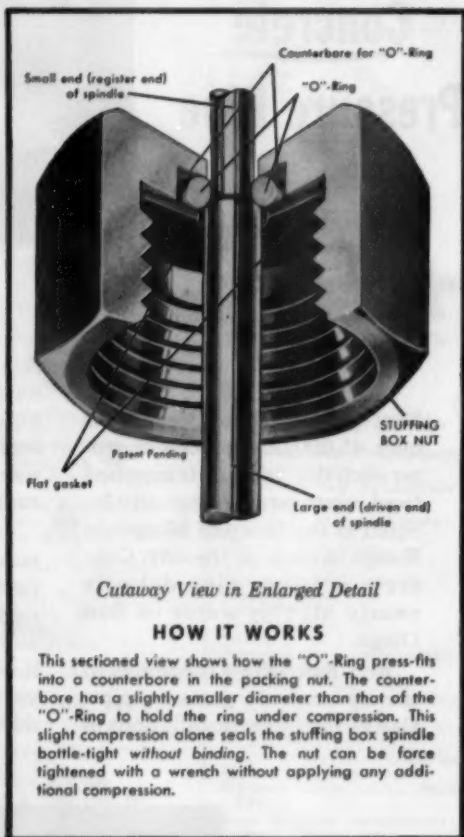
**Three Years of  
Proven Success  
In The Field**

The Rockwell "O"-Ring Stuffing Box Nut Assembly was perfected over three years ago. After extensive laboratory and field tests and without any "fan-fare" or publicity it has been used in Rockwell water meters built since that time. The superior performance of "O"-Ring construction is now a proven fact. It provides a permanent, leak tight seal at a very vulnerable point. And it actually improves meter performance by reducing friction at the stuffing box spindle. You get it only in Rockwell meters of all sizes and types. There's no extra cost, but a lot of extra value and satisfaction. Ask your Rockwell representative to demonstrate this great new advance in water meter construction.



**ROCKWELL MANUFACTURING COMPANY • PITTSBURGH 8, PA.**

Arlington Boston Charlotte Chicago Dallas Houston Los Angeles Midland, Texas  
N. Kansas City, Mo. New York Philadelphia Pittsburgh San Francisco Seattle Shreveport, La. Tulsa



#### HOW IT WORKS

This sectioned view shows how the "O"-Ring press-fits into a counterbore in the packing nut. The counterbore has a slightly smaller diameter than that of the "O"-Ring to hold the ring under compression. This slight compression alone seals the stuffing box spindle bottle-tight without binding. The nut can be force tightened with a wrench without applying any additional compression.

The Rockwell "O"-Ring assembly is also available as an economical replacement part. It is interchangeable with the stuffing box nuts on all earlier model Rockwell meters.

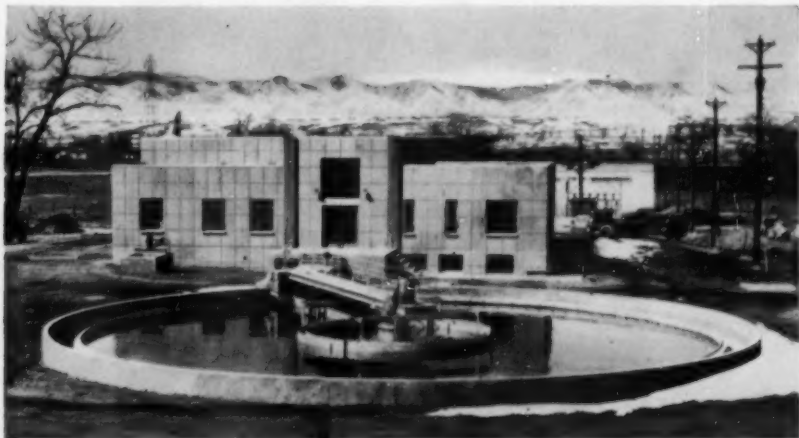
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**in water treatment problems...**

**you won't find identical twins**



No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job... and not vice versa.



## Englewood, Colorado

## Gets Turbidity Removal and Water Softening with One Hydro-Treator Unit

The problem at the City of Englewood, a suburb of Denver, was to get turbidity removal in the summer periods and water softening in the winter-time at a reasonable installed cost. The major source of the water supply is the South Platte River whose headwaters are fed by the snow stored in the Rocky Mountains.

A study of the problem involved showed that the Dorrco Hydro-Treator would handle both conditions efficiently. A 70 ft. diameter Hydro-Treator

with capacity of 7.5 MGD has done the job effectively. Now the water requirements at Englewood have increased due to population growth, and at this time an identical Hydro-Treator is being added to double treating capacity.

If you'd like more information on the complete line of Dorr-Oliver water treatment equipment, write for Bulletin No. 9141, Dorr-Oliver Incorporated, Stamford, Conn., or in Canada, 26 St. Clair Avenue E., Toronto 5.

*Every day, nearly 8 billion gallons of water are treated with Dorr-Oliver equipment.*

\*Hydro-Treator Trademark Reg. U. S. Pat. Off.

Consulting Engineer: DALE H. REA, Denver, Colorado



# DORR-OLIVER

INCORPORATED

WORLD - WIDE RESEARCH • ENGINEERING • EQUIPMENT

STAMFORD • CONNECTICUT • U. S. A.

# LEADITE

Trade Mark Registered U. S. Pat. Office

## Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains **MUST BE GOOD,—MUST BE DEPENDABLE,—**and that is just why so many Engineers, Water Works Men and Contractors aim to **PLAY ABSOLUTELY SAFE**, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

*The pioneer self-caulking material for c. i. pipe.  
Tested and used for over 40 years.  
Saves at least 75%*



**THE LEADITE COMPANY**  
Girard Trust Co. Bldg. Philadelphia, Pa.

# No Caulking

